MRP Properties Company, LLC
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Brenda B. Epperson
Manager
Environmental Liability & Remediation Management

September 30, 2014

Chief of the Hazardous Waste Permits Section
Kansas Department of Health and Environment
Bureau of Waste Management
ATTN: Mostafa Kamal, P.E., CHMM
1000 SW Jackson, Suite 320
Topeka, Kansas 66612-1366

U.S. Environmental Protection Agency, Region 7
Air and Waste Management Division
RCRA Corrective Action & Permits Branch
ATTN: Brad Roberts, P.G.
11201 Renner Boulevard
Lenexa, Kansas 66219

Re: **Response to KDHE Comments of September 3, 2014 on the Surface Water and Sediment HHRA Work Plan**
MRP Properties Company, LLC – Arkansas City, Kansas
EPA ID No. KSD087418695
VIA FEDERAL EXPRESS TRK#'s: 7713 3606 6440 / 7713 3602 9310

Dear Mr. Kamal and Mr. Roberts:

MRP Properties Company, LLC (MRP) has reviewed the Kansas Department of Health and Environment (KDHE) letter dated September 3, 2014 containing the comments from KDHE and EPA on the human health risk assessment (HHRA) work plan submitted by MRP on July 18, 2014. MRP's response to the KDHE and USEPA comments are provided in this letter.

The following presents the KDHE and EPA September 3, 2014 comments (*in italics*) followed by MRP's responses. The revised HHRA work plan pages are also attached.

<u>KDHE Comments:</u>

1. *Section 1.1.4 (p. 1-2). Please revise this section to note that human health risks associated with exposure to surface water and sediments at the active water treatment system ponds will be evaluated upon closure of the Solid Waste Management Units (SWMUs) associated with this system. The active water treatment system ponds include SWMU's 3, 4, 5, 6, 7, and 8.*

   Response:
   Agreed. Text was revised to indicate that these SWMUs will be evaluated upon closure.

2. *Section 2.1(p. 2-1). In Section 2.1 MRP states that the area of the site is approximately 260 acres whereas Section 1.1.1 lists the area as approximately 267 acres. Please verify the correct acreage for the site and revise for consistency.*

   Response:
   Agreed. Section 2.1 was updated to list the Site area as 267 acres.

3. *Section 2.1.1(pp. 2-1 and 2-2). In the last paragraph of Section 2.1.1, MRP states that storm water from the asphalt operation area is captured in a lift station and treated in the Oxidation Ponds before release to the Walnut River. Please revise the text to note*

that the asphalt area storm water is processed through the Bioreactor tank before release to the Oxidation Ponds.

Response:
Agreed. Text was updated to indicate that storm water runoff from the asphalt process area is captured in the lift station and sent to the North Bioreactor treatment tank (R-7101) before release to the oxidation ponds. Stormwater runoff from non-process areas at the north side of the site are captured in the storm water pond (SWMU 23) and then pumped to the backup (south) bioreactor tank (R-7102) and the oxidation ponds. All stormwater is managed in the oxidation pond system before discharge to the Walnut River through the NPDES permitted outfall.

4. *Section 3.2.1and 3.2.2 (pp. 3-2 to 3-4). Sections 3.2.1 and 3.2.2 discuss data collected from previous investigations of surface water and sediments (Tables 3-1 through 3-4) and propose additional sampling, but are not clear as to whether the existing data meets the data quality requirements for use in the baseline human health risk assessment. Upon review, usability of existing surface water and sediment data is questionable due to age, Walnut River levee improvements and river realignment, and lack of information relating to previous sampling locations. Please revise Sections 3.2.1 and 3.2.2 to state that existing data does not meet data quality requirements for inclusion in the surface water and sediments HHRA and will be used for historical reference only.*

   Response:
   Agreed. Text was revised to clarify that historic data do not meet the data requirements for inclusion in the HHRA.

5. *Section 3.2.1and 3.2.2 (pp. 3-2 to 3-4). Sections 3.2.1 and 3.2.2 make multiple references to a Data Gap Characterization Sampling and Analysis Plan document. KDHE and MRP have agreed that the title of the above named document incorrectly describes the intent of this document and that a more appropriate title would be "Surface Water and Sediment Investigation Work Plan". The Preliminary Corrective Action Project Schedule, included in the quarterly corrective action progress reports, has already been updated to reflect this change. Please replace all references to the Data Gap Characterization Sampling and Analysis Plan document with the appropriate title.*

   Response:
   Agreed. The title of the Surface Water and Sediment Investigation Work Plan was updated in text.

6. *Section 3.2.2 (p. 3-3). The first paragraph of Section 3.2.2 describes the proposed protocol for sediment sampling at SWMUs 9, 10, 11, and 23. The use of BER guidance document BER-RS-006 is acceptable for use in investigation of the stormwater ponds but the number of samples stated may not be sufficient for risk assessment purposes. The exact number of samples and sample locations will be addressed in the Surface Water and Sediment Investigation Work Plan. MRP may use composite samples for*

metals and SVOC analysis but discrete samples will be required for VOC analysis.

Response:
Agreed.

7. *Section 4.1.1(p. 4-1). The second paragraph in Section 4.1.1 defines the process for screening analytical data that will be included in the baseline HHRA.*

   a. *MRP states in the first sentence that detected soil concentrations will be used to screen analytes not related to site operations. Sampling will include both soil (sediment) and water (surface water). Please revise the text to include both soil and water concentrations.*

   b. *MRP states in the third sentence that surface water concentrations will be used in screening site related analytes. Screening should include both media addressed in the work plan. Please revise the text to include both surface water and sediment concentrations.*

Response:
Agreed. Text in Section 4.1.1. was revised as indicated.

8. *Section 4.2.2 (p. 4-5). MRP states that the Exposure Point Concentrations (EPCs) for sediment in the storm water retention ponds will be based on three composite samples from each pond. Composite sediment samples will not be allowed for analysis of VOCs. Please refer to Comment #6.*

Response:
Agreed.

9. *Section 4.2.4 (p. 4-9). MRP references a Unit Risk Factor (URF) when calculating Incremental Lifetime Carcinogenic Risk (ILCR). Current EPA terminology has replaced URF with Inhalation Unit Risk (IUR) when calculating carcinogenic inhalation risk. Please replace references to the URF with the current terminology.*

Response:
Agreed. Unit Risk Factor was replaced with Inhalation Unit Risk.

10. *Section 5.0 (p. 5-1). Section 5.0 contains the list of references cited in the HHRA Work Plan for Surface Water and Sediment. Section 3.2.2 cites K.DHE (1996) as the document to be referenced for sediment sampling at the storm water retention ponds (SWMUs 9, 10, 11, and 23), but no reference is listed in Section 5.0. Please revise Section 5.0 to include the reference document cited as KDHE (1996).*

Response:
Agreed. KDHE (1996) was added to the reference section.

11. *Figure 4-1. The Conceptual Site Model for the facility is described in Sections 4.1.2.1 through 4.1.2.2 and depicted in Figure 4-1. The exposure pathways described in Sections 4.1.2.1 through 4.1.2.2 for on- site sediment in the storm water retention ponds and off-site sediment in the Walnut River do not match the exposure routes shown in Figure 4-1. Please verify and revise Figure 4-1 as necessary.*

    Response
    Agreed. Section 4.1 and Figure 4-1 was revised to ensure consistency.

EPA Comments:

1. ***Sections 3.2.1 and 3.2.2 (p. 3.3).*** *Details on sampling locations, procedures, and methods will be described in a separate Surface Water and Sediment Investigation Work Plan. The EPA ecological and human health risk assessors look forward to reviewing these details. For instance, we would like to know how the sediment samples will be collected (e.g., Ponar grab, etc.).*

   We read on page 4-2 that impacted off-site sediment has been covered or separated from the current river channel. If possible, we suggest that MRP attempt to locate historical records such as the location and depths of the Walnut and Arkansas Rivers and associated levees, prior to modifications made by the Army Corps of Engineers. We also suggest consideration of how stormwater exited the site before implementation of the NPDES-permitted capture/treatment/outfall system. These considerations may help MRP hypothesize where the highest levels of contamination in off-site sediment and surface water are currently located, understanding that the likelihood of potential exposure by human and ecological receptors is equally important when determining sampling locations.

   Response
   There is a paucity of historic information regarding river channel morphology adjacent to the Site and storm water flow paths prior to implementation of the NPDES permit beyond the former shoreline indicated in Figure 2-2 of the HHRA WP for Surface Water and Sediment and archived aerial photographs that include a limited level of detail. Any additional evidence will be considered in the sampling design and documented in the Surface Water and Sediment Investigation Report.

2. ***Section 3.2.2 (p. 3-3).*** *The sediment samples planned for the stormwater ponds include a composite of discrete samples collected from each of four quadrants in each pond bottom. Page 3-3 indicates that these samples will be collected from 0 to 2 feet below ground surface. Later, page 4-3 explains that this depth was selected due to the extremely shallow groundwater table. Samples from 0 -2 ft bgs are appropriate for evaluating potential risks to construction workers involved in digging, expanding, or moving these ponds; however, it is more appropriate to collect samples from the surface (i.e., 0 – 2 cm bgs) to evaluate potential risks to groundskeepers. We recommend collecting on-site sediment samples from both the surface and the 0 -2 ft bgs depth intervals. An exception could be made if we had evidence to suggest that contamination levels were higher at the surface or at depth, but we do not believe*

sufficient data is available to make this determination at this site.

Response
Agreed. Sediment samples will be collected from the surface as well as from the 0 - 2 feet bgs to quantify potential exposures to groundskeepers and construction workers, respectively. The surface sediment samples from the stormwater ponds will be collected from 0 to 2 inches below ground surface, consistent with the sample depth used for the Walnut River (refer to Comment Number 6b).

3. ***Tables 3-1 and 3-2.***

   a. *Chromium should be compared to the EPA's tap water regional screening level of 0.035 μg/L for chromium (VI) since data on the species of chromium present at this site are not available.*

   Response
   Please note that as described in KDHE Comment No. 4, historic data are provided for reference only, and will not be utilized in the risk assessment calculations. Speciated chromium data will be collected, including hexavalent chromium, and analytical results will be compared to the appropriate regional screening level.

   b. *Lead should be compared to the Maximum Contaminant Level of 15 μg/L, rather than 0.28 μg/L, unless tetraethyl lead was used or has been present at this site in which 1.3E-04 μg/L is the appropriate RSL.*

   Response
   Agreed. The surface water screening level for lead in Tables 3-1 and 3-2 has been revised to reflect the MCL of 15 ug/L. Regarding tetraethyl lead (TEL), TEL was used at the facility. However, it was only blended into fuel product as it was loaded into tank cars. Leaded gasoline was not stored in ASTs at the site. As a result, the potential for TEL to have impacted the Process Area, Former Tank Farm or stormwater ponds is minimal. For this reason, TEL was not included in the soils investigation for the Process Area or the Former Tank Farm. Therefore, we do not propose to sample for TEL in surface water or sediment samples.

   c. *Please ensure that the tap water RSLs used in the risk assessment are based on a 1E-06 excess cancer risk or a non-cancer hazard quotient of 0.1, as stated in Section 4.1.1. For example, the RSLs for toluene, xylene, anthracene, and others are based on an HQ of 1, not 0.1.*

   Response
   Agreed, non-cancer effects based screening values will be based on an HQ of 0.1.

4. ***Tables 3-3 and 3-4.*** *Chromium should be compared to the EPA's industrial soil RSL of 6.3 mg/kg for chromium (VI).*

Response
Please note that as described in KDHE Comment No. 4, historic data are provided for reference only, and will not be utilized in the risk assessment calculations. Speciated chromium data will be collected, including hexavalent chromium, and analytical results will be compared to the appropriate regional screening level.

5. ***Figure 4-1 and Section 4.1.2.2 (p. 4-3).*** *MRP plans to evaluate exposures to on-site surface water and sediment (i.e., the stormwater retention ponds) by future industrial/commercial workers (i.e., maintenance-type workers) and future utility / construction workers (i.e., those involved in expanding, modifying, or moving the ponds). Evaluation of off-site exposure to surface water and sediment (i.e., the Walnut River) is planned for current/future recreational receptors.*
   a. ***On-Site Surface water.*** *In contrast to Figure 4-1, we would consider inhalation of volatiles in outdoor air from on-site surface water to be a de minimis pathway.*

      Response
      Agreed. Figure 4-1 was revised to indicate that inhalation of volatiles in outdoor air from on-Site surface water is a complete but insignificant exposure pathway; this pathway will not be quantitatively evaluated in the HHRA for Surface Water and Sediment.

   b. ***On-Site Sediment.*** *In contrast to Figure 4-1 but in agreement with page 4-3, we would evaluate exposures to volatiles and particulates in outdoor air originating in sediment (via a volatilization factor or particulate emission factor) by future industrial/commercial and utility/construction workers. Although we typically would not anticipate particulate emissions from sediment, these particular stormwater ponds are dry most of the year, so we believe dust could be generated.*

      Response
      Agreed. Figure 4-1 was revised to indicate that inhalation of volatiles and particulates in outdoor air originating from dry sediment by a future industrial/commercial and utility/construction worker will be quantitatively evaluated.

   c. ***Future On-Site Construction Workers*** *vs.* ***Utility Workers.*** *We suggest that MRP need only to evaluate potential future exposures to on-site sediment and surface water by construction workers, not by utility workers. This is because both types of workers would likely be exposed to the same depth of material due to the very shallow groundwater table and because construction workers would likely be exposed for a greater length of time. In the risk assessment, MRP may indicate that evaluation of risks to construction workers is protective of utility workers.*

      Response
      Agreed. The construction / utility worker scenario is designed to evaluate

exposures for the more highly exposed construction worker, and is therefore protective of the utility worker. The construction / utility worker terminology is consistent with the Human Health Risk Assessment Work Plan for Soil and Groundwater (MWH, 2014), and was therefore retained for the Human Health Risk Assessment for Surface Water and Sediment even though only a single scenario is evaluated. This was clarified in Section 4.1.1.2.

d. ***Off-Site Sediment.*** *Figure 4-1 does not indicate that inhalation of volatiles or particulates derived from off-site sediments by recreational receptors are complete pathways. In the risk assessment, we suggest a qualitative discussion of these potential pathways. For example, perhaps the concentrations of volatiles in sediment are minimal, so inhalation of volatiles is de minimis. Perhaps the sediment along the Walnut River is generally wet, precluding the generation of dust and rendering this an incomplete pathway. These are merely possibilities; please consider actual conditions along Walnut River when formulating the discussion.*

Response
Figure 4-1 and Section 4 text was revised to indicate that inhalation of volatiles or dust from off-Site sediment is an incomplete exposure pathway because potentially impacted sediment is continually inundated.

6. ***Section 4.1.2.2 (p. 4-3).*** *The last paragraph of this section describes how recreational receptors could be exposed to off-site surface water and sediment.*

a. *Page 4-3 indicates that neither swimming nor wading will be evaluated, but we evaluate recreational exposures to surface water assuming one or the other, depending on the water depth. Please determine which scenario is more likely. We would tend to use an upper end water surface water ingestion rate while swimming and a mean ingestion rate to represent less consumption during a wading scenario. See Comment 10e.*

Response
The portion of the Walnut River adjacent to the Site is not suitable for swimming due to swift currents and levees, and a recreational visitor is also not expected to use the area for wading. However, the recreational fisher will conservatively be evaluated under a wading scenario. In addition to increased potential for dermal contact, the surface water ingestion rate for the recreational user was increased to account for wading, as described in Comment 10e.

b. *Page 4-3 also indicates that recreational users could be exposed to off-site sediment down to 2 ft bgs. Please explain. If receptors would be more likely to be exposed to sediment only at the surface, please be sure to collect off-site sediment samples only from the 0 – 2 cm (or inches) bgs depth interval.*

Response
Recreational receptors are most likely to be exposed to surface sediment only; Walnut River sediment samples will be collected from the top two inches.

7. ***Section 4.2.2 (p. 4-5).*** *Due to the limited number of samples planned, please be aware that the maximum detected concentrations (or maximum reporting limits) will be used as the exposure point concentrations. Insufficient data will be available to calculate 95% upper confidence limits on the means.*

   Response
   Agreed. The maximum detected concentration will be used as the exposure point concentration.

8. ***Section 4.2.2.1 (pp. 4-5 and 4-6).*** *In the risk assessment, please be sure to use Exhibits 1-2 and 1-3 in RAGS Part E to determine whether it is necessary to evaluate dermal exposures to COPCs in surface water and sediment, respectively.*

   Response
   Agreed. Exhibits 1-2 and 1-3 in RAGS Part E will be used to evaluate whether it is necessary to evaluate dermal exposures to COPCs in surface water and sediment. This additional screening for the dermal pathway was described in Section 4.2.2.1.

9. ***Section 4.2.2.1 (p. 4-7).*** *The equation for 'Noncancer Inhalation of Volatile COPCs in Surface Water" is not necessary for this risk assessment. See Comment 5.*

   Response
   Agreed.

10. ***Table 4-1.***

    a. *The Agency has recently updated the standard default exposure parameters. Please revise the exposure parameters used in Table 4-1 accordingly. http://www.epa.gov/oswer/riskassessment/pdf/superfund-hh-exposure/OSWER-Directive-9200-1-120-ExposureFactors.pdf*

       Response
       Agreed. The exposure parameters in Table 4-1 were revised according to the updated standard default exposure parameters.

    b. *A child or youth recreational user of Walnut River should be evaluated, either in addition to or in place of an adult, in order to be protective. MRP should use their best judgment regarding the age of receptors that fish, swim, or wade in the river. Two suggestions are ages 6 to 16 years or 11 to 16 years of age. The age selected will determine the appropriate body weight, skin surface area, etc.*

       Response
       Agreed. The recreational receptor scenario was modified such that a composite

adolescent (11 to 16 years of age) and adult receptor will be used to evaluate cancer risk, while an 11 to 16 year old adolescent will be used to evaluate non-cancer hazard.

c. *For the construction worker scenario, an exposure frequency of 50 days seems conservative, but possible, given the size of the stormwater ponds. Please be aware that non-cancer hazards should be averaged over the duration of the project. For example, if workers are at their jobs 5 days per week, an exposure frequency of 50 days would take 10 weeks or 70 days. Thus, the non-cancer averaging time would be 70 days. Note that the value of "ED" for the construction worker scenario would still be one year because it is merely used to convert units in the exposure equations.*

   Response
   Comment noted. The exposure duration of one year presented in the HHRA Work Plan for Soil and Groundwater will be used in the HHRA for Surface Water and Sediment for consistency; a construction project at the Site might last a year, but only involve sporadic exposures to the stormwater ponds.

d. *A total exposure frequency of 45 days per year seems justified for an outdoor maintenance worker based on the discussion provided. If there is any documentation on how frequently on-site workers were exposed to the ponds in the past, this would also add to the discussion.*

   Response
   Documentation of grounds keeping frequency is not available; however, personal communication with MRP staff indicates that mowing occurs once per week April through September, therefore an exposure frequency of 26 days per year will be used.

e. *An incidental surface water ingestion rate of 10.6 mL/hr was selected for the outdoor maintenance worker, the construction worker, and for recreational fishing. This value is the upper end value from a study on simulated fishing in a swimming pool, taken from Table 3-93 of the 2011 Exposure Factors Handbook.*

   Prior to the 2011 EFH, Region 7 has used 50 mL/event to evaluate incidental water ingestion during wading and 50 mL/hr to evaluate swimming scenarios. Recently, we have used mean values in Table 3-5 of the 2011 EFH to evaluate wading scenarios and upper limit values from Table 3-5 to evaluate swimming scenarios. Table 3-5 provides the recommended values for swimming; data was deemed insufficient to provide standard recommendations for other scenarios.

   At this site, MRP may use the 10.6 mL/hr for incidental ingestion by maintenance workers and fisherpersons. However, in an attempt for consistency across Region 7 sites, please use the mean incidental water ingestion rate of 21 *mL/hr for construction workers. Because workers involved in digging out, expanding, or moving the ponds would be expected to have greater contact with surface water, we believe this value is justified. Please determine if wading or swimming is more likely at this site, based on the depth of the Walnut River. If wading is selected, please use the mean recommended values from Table 3-5 to evaluate off-site recreational exposures, and if swimming is selected, please use the upper percentile values. The "per event" values in this table are based on swimming for 45 minutes.*

Response

Agreed. An incidental ingestion rate of 21 mL/hr will be used for construction workers. As requested in Comment Number 6a, wading exposures was added to the evaluation of an off-Site recreational receptor fishing in the Walnut River. The mean recommended water incidental ingestion rate of 49 mL/hour for a child [adolescent] and 21 mL/hour for an adult from Table 3-5 of EPA (2011) was added to Table 4-1.

If you have any questions or comments regarding the response to these comments, please contact me at 210/345-4619 or Jay Mednick, MWH at 303/291-2262.

Sincerely,

BB Epperson

Brenda B. Epperson

Enclosures: Revised HHRA Work Plan; Redlined: Text, Tables, Figures; and CD

cc: Mark Vishnefske, KDHE BWM w/o enc.
Kent Biggerstaff – MRP Properties Company, LLC
Jay Mednick – MWH
Bruce Narloch – MWH

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Human Health Risk Assessment Work Plan for Surface Water and Sediment

Former Total Petroleum Refinery
Arkansas City, Kansas

PREPARED FOR:

MRP Properties Company, LLC.
1400 South M Street
Arkansas City, Kansas 67005

PREPARED BY:

MWH

BELLEVUE, WASHINGTON

AND

DENVER, COLORADO

DATE:

JULY 18
REVISED SEPTEMBER 30, 2014

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LIST OF ACRONYMS AND ABBREVIATIONS

°F	degrees Fahrenheit
$\mu g/m^3$	micrograms per cubic meter
ABS_{GI}	oral absorption efficiency
AMSL	above mean sea level
AST	aboveground storage tank
bgs	below ground surface
CA	Canadian Fine Silty Loam
CDL	Construction Debris Landfill
CMS	Corrective Measures Study
cm^2	square centimeters
COPC	constituent of potential concern
CSF	cancer slope factor
CSM	conceptual site model
DA	Dale Silt Loam
EPC	exposure point concentration
EUs	Exposure Units
FCC	fluid catalytic cracker
ft	feet
FTF	former Tank Farm
EUSSI	Exposure Unit Supplemental Soil Investigation
HEAST	Health Effects Assessment Summary Tables
HFA	hydrofluoric acid
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
ILCR	incremental lifetime cancer risk
IUR	inhalation unit risk
IRIS	Integrated Risk Information System
JSA	Junk Storage Area
kg	kilograms
kg/mg	kilograms per milligram
KDHE	Kansas Department of Health & Environment
LG	Lincoln-Tivoli Complex
LTU	Land Treatment Unit
LUCs	land use controls
m^3/kg	cubic meters per kilogram
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/cm^2-day	milligrams per square centimeters per day
mg/m^3	milligrams per cubic meter
$mg/\mu g$	milligrams per microgram
MRP	MRP Properties Company, LLC
MDL	method detection limit
MRL	method reporting limit

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MWH	MWH Americas, Inc.
NPDES	National Pollutant Discharge Elimination System
PA	Process Area
PAH	polycyclic aromatic hydrocarbon
PID	photoionization detector
PPRTV	Provisional Peer Reviewed Toxicity Values
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RfC	reference concentration
RfD	reference dose
RFI	RCRA Facility Investigation
RSL	Regional Screening Level
SLERA	Screening Level Ecological Risk Assessment
SSB	Supplemental Soil Borings
SSI	Supplemental Soil Investigation
SVOC	semivolatile organic compound
SWMU	solid waste management unit
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
VD	Verdigris Silt Loam
VISL	Vapor Intrusion Screening Level
VOC	volatile organic compound
VSI	visual site inspection
Work Plan	HHRA Work Plan

1.0 INTRODUCTION

This human health risk assessment (HHRA) work plan for surface water and sediment was prepared by MWH Americas, Inc. (MWH) on behalf of MRP Properties Company, LLC (MRP) for the former Total Petroleum Refinery in Arkansas City, Kansas (the Site). In support of Resource Conservation and Recovery Act (RCRA) Corrective Measures Study (CMS) activities for the Site, MRP submitted a draft Human Health Risk Assessment (HHRA) Work Plan on January 25, 2013, and a Data Gap Investigation (DGI) Work Plan on February 11, 2013, to the Kansas Department of Health & Environment (KDHE) and the U.S. Environmental Protection Agency Region 7 (USEPA). The KDHE and USEPA provided written comments, dated July 19, 2013. Among other comments, the agencies requested that MRP conduct a baseline HHRA for surface water and sediment, and an ecological risk assessment (ERA) for soil, surface water, and sediment. This Work Plan outlines the methods and assumptions to be used in the preparation of a baseline HHRA for surface water and sediment at the Site. Methods and assumptions to be used in an ERA for soil, surface water, and sediment will be presented in a separate work plan.

1.1 BACKGROUND

1.1.1 Site Location and History

MRP is the current owner of the Site, which is located at 1400 South M Street in Arkansas City, Cowley County, Kansas. The Site occupies approximately 267 acres located within parts of Section 31 and 32 of Township 34 South and Range 4 East; and Section 5 of Township 35 South and Range 4 East, near the confluence of the Walnut River and the Arkansas River. The eastern boundary of the Site is approximately ½ mile upstream of the confluence of the two rivers, as shown on Figure 1-1. A U.S. Army Corps of Engineers (USACE) levee system along the Arkansas and Walnut rivers protects Arkansas City and the Site from floods.

The former Total Petroleum Inc. (Total) refinery was constructed in the 1920s, and operational until 1996; the Site is currently regulated under a RCRA post closure care permit with KDHE as the lead agency. A RCRA Facility Investigation (RFI) Report (completed August, 1992), a Phase II RFI Report (completed June, 2000), and USEPA's Environmental Indicator (EI) process determined Groundwater Migration and Current Human Exposures were under control (USEPA, 2000a, 2000b). A Corrective Measures Study (CMS) work plan (completed February, 2002), and a corrective action objectives document (completed May, 2005) have been approved by the USEPA (May, 2005). In addition, an EUSSI Report was prepared for a portion of the Site and submitted to the agencies in April 2011. In a May 24, 2012 letter from KDHE, the agencies noted that the EUSSI Report was intended to be used for risk screening and not as a baseline risk assessment. As such, no further changes to the EUSSI were necessary; however, the agencies requested that MRP consider comments on the EUSSI when developing baseline risk assessment methods.

Since initial operation in the 1920s, the Site has had several different owners. The Site was purchased by Total in April 1978 and this entity was the last owner to operate the former refinery. Refining operations (alkylation, crude, hydrocracker, reformer, etc.) at the facility were discontinued September 1996. The process units in the main process area and a majority of the

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tanks associated with the refinery were demolished by 2003. Figure 1-2 contains a plan delineating major areas at the Site. Current Site use consists of a terminal operation where asphalt is transported by truck to the terminal, stored, and then transported by truck to customers. The terminal does not process, mix, or blend asphalt at the Site.

As a result of this long history of refining activity, petroleum is present in the subsurface at the Site. Hydrocarbon recovery from both the saturated and unsaturated zone has been ongoing since the early 1940s. A formal groundwater restoration program (hydrocarbon recovery) was initiated in 1982.

1.1.2 Surface Water Features

On-Site surface water exists in two primary impoundment types: active treatment ponds that comprise the final stages of the groundwater treatment system, and seasonally wet stormwater detention basins. These impoundments are described in greater detail in Section 2.1.2; however, human health exposures associated with active water treatment ponds will not be quantitatively evaluated at this time.

Off-Site surface water exists primarily in the Arkansas and Walnut Rivers; the relationship between these rivers and the Site, including potential sources of contamination, is described in Section 2.1.2.

1.1.3 Previous RCRA Investigations

A sediment and surface water characterization was conducted in 1989 and 1990 followed by a soil and groundwater investigation in 1990 culminating in the Final RFI Report (RSA, 1992). These investigations addressed soil, groundwater, surface water, and sediment at the Site. Additional delineation was conducted as part of a Phase II RFI investigation in 1999. The results of soil and groundwater investigations for the Site are described in the HHRA Work Plan for Soil and Groundwater (MWH, 2014); surface water and sediment investigation results are summarized in Section 3 of this Work Plan.

1.1.4 Future Site Use and Risk Assessment Framework

The Site is currently zoned industrial, and the most likely scenario for future land use at the Site is redevelopment as commercial or industrial properties. Under this future land use, it is likely that the current stormwater retention ponds will remain in use. In the event that land use for these ponds changes, the basins will likely be backfilled, eliminating exposure for future receptors.

Use of the active treatment system ponds will most likely continue unchanged until the groundwater protection standards (GWPS) are achieved at the downgradient boundary of the Site, and therefore MRP is not seeking to close units associated with the treatment system at this time. Per discussion with KDHE, evaluation of potential human health risk associated with exposure to surface water and sediment at the active treatment system ponds will be performed upon closure of the units (i.e., SWMUs 3, 4, 5, 6, 7, and 8) associated with this system.

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1.2 PURPOSE AND SCOPE

The purpose of this Work Plan is to describe the methods and assumptions that will be used during the preparation of a baseline HHRA for surface water and sediment for the Site, including an evaluation of existing data and additional data requirements. Human health cancer risk and noncancer hazard estimates associated with impacted surface water and sediment will be calculated following additional Site characterization to address data gaps for these media.

1.3 ORGANIZATION

This Work Plan consists of five sections, as described below.

- **Section 1.0 – Introduction:** Summarizes the Site background and presents the purpose and scope and organization of this Work Plan.
- **Section 2.0 – Project Setting:** Presents detailed descriptions and operational histories for the Site, and summarizes the environmental setting.
- **Section 3.0 – Data Summary and Evaluation:** Presents existing Site characterization data, and describes the data usability requirements for environmental data that will be used in the HHRA for surface water and sediment.
- **Section 4.0 – Human Health Risk Assessment Approach:** Describes the methods and assumptions to be used in the preparation of a baseline HHRA for surface water and sediment at the Site.
- **Section 5.0 – References:** Lists the references cited in this Work Plan

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2.0 PROJECT SETTING

A general description of the Site setting is presented in this section.

2.1 FACILITY DESCRIPTION

The Site is located southeast of the incorporated limits of Arkansas City in southwestern Cowley County, Kansas. It occupies approximately 267 acres northwest of the confluence of the Walnut and Arkansas Rivers. Petroleum refining facilities occupied the former Process Area (PA) in the northern portion of the Site, while the former Tank Farm, Construction Debris Landfill (CDL), Land Treatment Unit (LTU), former Junk Storage Area (JSA), and waste water treatment system occupied the southern portion of the Site. Refining facilities and infrastructure have been removed; however, former surface water impoundments remain in use for stormwater detention and as the final stages of the groundwater treatment system.

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2.1.1 Site Operations

The former refinery, which was operational from the 1920s until September 1996, produced unleaded gasoline, liquefied petroleum gas (LPG), propylene, fuel oils, jet fuels, and asphalt at a nominal operating capacity of 60,000 barrels per day. The refinery received approximately 85% of its crude oil supply by pipeline and transported approximately 85% of its refined products by pipeline. The remaining product was transported by truck. The integrated refining processes included two crude fractionation units, a hydrofluoric acid (HFA) alkylation unit, two catalytic reformers, gas plant, hydrocracker, propylene splitter, sulfur recovery plant and other supporting facilities.

As a result of the long history of refining activity, petroleum is present in the subsurface in portions of the Site. Hydrocarbon recovery from both the saturated and unsaturated zone has been ongoing at the Facility since the early 1940s. In 1982, Total initiated a formal groundwater restoration program (hydrocarbon recovery) within the main part of the Site. The hydrocarbon recovery program has resulted in the installation of more than 100 groundwater monitoring wells and numerous product recovery wells throughout the Site. Most of the monitoring wells were installed for the purpose of delineating the areal extent and thickness of hydrocarbon in the groundwater beneath the Site. The current groundwater containment system operates as a corrective action requirement of the facility's Hazardous Waste Management Permit and an interim measures hydrocarbon recovery system within the Site to recover free phase hydrocarbon product. Solid waste management units (SWMUs) 4, 5, 6, 7, and 8, also known as Oxidation Ponds 1A, 1B, 2, 3, and 4, respectively, comprise the final legs of this groundwater treatment system.

Decommissioning has eliminated most of the structures at the Site including buildings, refinery process units, the tank farm, and underground piping to six feet below ground surface. Currently, a portion of the Site is used as an asphalt distribution terminal. The asphalt is received from off-Site sources via truck and then transported off-Site to customers via truck. Asphalt is not processed, blended, or mixed at the Site. Storm water runoff from the asphalt process area is captured in the lift station and sent to the North Bioreactor treatment tank (R-7101) before release to

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the oxidation ponds. Storm water runoff from non-process areas at the north side of the site are captured in the storm water pond (SWMU 23) and then pumped to the backup (south) bioreactor tank (R-7102) and the oxidation ponds. All stormwater is managed in the oxidation pond system before discharge to the Walnut River under the facility's National Pollution Discharge Elimination System (NPDES) permit.

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2.1.2 Surface Water Features

As mentioned in Section 1.1.2, on-Site surface water exists in two primary impoundment types: active treatment ponds that comprise the final stages of the groundwater treatment system, and seasonally wet stormwater retention basins. These impoundments are described below and shown on Figure 2-1, however, as described in Section 1.1.4, based on a discussion between representatives of MWH and KDHE on May 7, 2014, potential human health risks associated with exposure to ponds in the active treatment system will not be quantified in the HHRA for surface water and sediment.

2.1.2.1 Groundwater Treatment System Ponds

In the final stages of the treatment system, groundwater flows from the bioreactor tank to Oxidation Pond No. 1A (SWMU 4), Oxidation Pond No. 1B (SWMU 5), Oxidation Pond 2 (SWMU 6), Oxidation Pond No. 3 (SWMU 7), and finally to Oxidation Pond 4 (SWMU 8) for additional biodegradation of organic compounds before discharge through a NPDES outfall to the Walnut River.

2.1.2.2 SWMUs 9, 10, 11, (Evaporation Ponds 1, 2, and 3) and SWMU 23 (Stormwater Pond)

Evaporation Ponds No. 1 through No. 3 (SWMU 9, 10, and 11) were constructed from native soil around 1956 to manage stormwater from non-process areas, and are still in use. Water in this system flows from the 375,000 gallon capacity Evaporation Pond No. 1 to the 500,000 gallon capacity Evaporation Pond No. 2 and finally to the 500,000 gallon capacity Evaporation Pond No. 3. The stormwater ponds are six to seven feet deep, and 7,000 to 10,000 square feet in surface area.

During the history of the refinery, water in Evaporation Pond No. 1 sometimes contained a sheen, and during the visual site inspection (VSI) staining was observed along the embankment (A.T. Kearney, Inc. and Harding Lawson Associates, 1987). Also during the VSI, a scum layer was observed on the water surface in Evaporation Pond No. 2, and light staining was observed on the dikes around Evaporation Pond No. 3 (A.T. Kearney, Inc. and Harding Lawson Associates, 1987).

The No. 1 Oil Trap (SWMU 23) was used to manage oily waste water beginning in the 1930s, and later to contain spills and stormwater. There is no documentation of how water and sludge were managed during this use. The No. 1 Oil Trap was removed from service in December 1986. A stormwater pond now occupies the location of the previous No. 1 Oil Trap.

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Stormwater detention ponds contain little to no water during most of the year (personal communication, July 10, 2014).

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2.1.2.3 Closed Surface Impoundments

The No. 1 and No. 2 closed surface impoundments (SWMUs 1 and 2) and the No. 3A aerated lagoon (part of SWMU 3) are RCRA-regulated units. These units are currently in RCRA post closure care and do not require further risk assessment.

2.1.2.4 Walnut River Surface Water

Off-Site surface water includes the Walnut and Arkansas Rivers. All stormwater runoff is contained on-Site and only discharged according to NPDES permit requirements, however, off-Site surface water and sediment may have become contaminated at historic hydrocarbon seep areas. The Arkansas River is upgradient of the Site, and is therefore not likely to have been impacted. Seeps to the Walnut River have been observed north of the Site, and near the NPDES outfall, as shown in Figure 2-2. The historic seeps were reported as a sheen on the river, and were addressed by physical barriers to prevent further off-Site migration. Currently, groundwater flow to the Walnut River is limited by the groundwater capture and treatment system; extracted and treated groundwater is discharged to the Walnut River at the NPDES permitted outfall.

NDPES discharge monitoring data indicate no impacts to the Walnut River. Exposures to sediment impacted by historic discharges is incomplete due to levee realignment work performed between 2002 and 2005 which included expanding the footprint and raising the Walnut River levee adjacent to the Site, and shifting the Walnut River away from the Site to the north and east (Figure 2-2) into formerly dry land that was excavated. The exposure pathway to current and future receptors to any historic contamination is not complete. However, sampling in the Walnut River will be conducted as described in Section 3.2 to document current conditions and determine if further evaluation is warranted.

2.2 ENVIRONMENTAL SETTING

The majority of the land surrounding the Facility is cultivated for wheat and sorghum production. A large flour mill borders the Site to the north, the area to the northwest is residential, a recreational area and the Arkansas City sewage treatment plant lie directly west of the Site, and the Kaw Wildlife Area is located to the south and southeast. The direction of groundwater flow at the Site is to the northeast. Several active oil production wells are located in the vicinity. Currently, minimal industrial activity associated with the small asphalt terminal occurs at the Site. Future land use at the Site is expected to remain industrial or commercial. The Site currently contains no significant habitat for wildlife, and enhancement for wildlife use is not planned.

2.2.1 Site and Vicinity Land Use

The Site is currently zoned industrial, and land use at the Site is expected to remain industrial. Land directly to the west is zoned single family residential. The area to the southwest is zoned

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heavy industrial and is the location of the Arkansas City sewage treatment plant. Land use to the north is limited industrial, including a large flour mill on the northern border. A gravel mining operation is present in industrial land to the south, and the Kaw wildlife management area is located adjacent to the site to the south and southeast. The nearest residential property east of the Site is over a quarter of a mile away across the Walnut River.

The regional and local setting of the facility is summarized in the following sections. Regional hydrogeology was investigated as part of the RFI and submitted with the August 4, 1992 Final RFI Report (RSA, 1992).

2.2.2 Geology and Soils

The Site has very little topographic relief and gently slopes towards the northeast. Facility elevations range from approximately 1,078 feet above mean sea level (AMSL), near the southern boundary of the facility, to 1,045 feet AMSL, at the east side of the facility.

The Site is located southeast of Arkansas City in Cowley County, in south central Kansas. Structurally, this area is east of the Nemaha Ridge, and west of the Dexter Anticline. Locally, the facility is located at the confluence of the Arkansas and Walnut Rivers. The region is underlain by Permian-age rocks that dip toward the west (Bayne, 1962). Quaternary alluvium overlies these Permian deposits and is found along major rivers and streams.

The areas along both the Arkansas and Walnut Rivers, including the Site, are underlain by unconsolidated Quaternary-age alluvial deposits. These deposits consist of clay, silt, sand, chert, and limestone gravel (RSA, 1992). The thickness of alluvial deposits in the region is typically less than 25 feet, although recent alluvial deposits along the Arkansas River can be as much as 50 feet in thickness.

The alluvial deposits are underlain by the bedrock of the Permian-age Chase Group which is comprised of interbedded limestone, chert, and shale. The Chase Group has a total thickness of about 350 feet; about half of which is limestone and the other half shale (Bayne, 1962). Bedrock dips to the west, with younger Permian rocks of the Sumner Group regionally overlying the Chase Group. The Chase Group overlies older Permian rocks of the Council Grove and Admire Groups. Progressively older lithologies are exposed at the surface east of the Site.

There are three prominent structures in Cowley County, the Dexter Anticline, the Winfield Anticline, and the Nemaha Anticline. The Dexter Anticline is located in the eastern part of the county and trends northeast-southwest. The east flank has a dip of over 200 feet per mile, while the west flank has a dip of about 100 feet per mile. The Winfield Anticline, which trends northeast-southwest in the central part of the county has a dip less than the Dexter Anticline but can be observed in surface features. The Nehema Anticline extends from central Oklahoma to northeast Kansas, and crosses the northwestern corner of the County. None of these structural features significantly affects the geology at the Site.

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According to the United States Department of Agriculture (USDA) Soil Survey of Cowley County (1980), there are four soil types found at the facility; the Canadian Fine Silty Loam (CA), the Dale Silt Loam (DA), the Lincoln-Tivoli Complex (LG) and the Verdigris Silt Loam (VD).

The Canadian series (CA) soil is generally deep, well drained, with moderately rapid permeability. This soil type ranges in depth up to about 60 inches and is formed in loamy and sandy alluvium. Slopes of this soil type range from 0 to 1 percent. Canadian series soil is generally located in the southern portion of the Site.

The Dale series (DA) soil type is generally deep, well drained and moderately permeable. Soil depths extend to about 60 inches, and are formed in loamy alluvium. This soil type has slopes of about 0 to 1 percent and trend in an east-west direction in the central portion of the facility.

The Lincoln-Tivoli Complex (LG) soil type tends to be a deep soil that is excessively drained with rapid permeability. The depth of this soil type occurs within the upper 60 inches. This soil type is found on floodplain or terrace deposits. Slopes of this soil type range from 0 to 15 percent and are found along the Arkansas and Walnut Rivers at the northeastern and southern boundaries of the facility.

The Verdigris Series (VD) soil type is deep and moderately well drained and has moderate permeability. Soil depths extend to about 60 inches and form in silty alluvium. Slopes of this soil type are about 0 to 2 percent and are found on low terraces and floodplains. The Verdigris soil type is located on the northern side of the facility.

2.2.3 Hydrogeology

Groundwater occurs in alluvial and bedrock aquifers in the vicinity of the Site. The alluvial deposits along the Arkansas River Valley provide large quantities of water (500 to 1,000 gallons per minute) which ranges in quality from good to poor. Locally, groundwater from bedrock aquifers can yield large to small quantities of water that ranges from good to poor quality. Chloride concentrations in water wells completed in alluvial sediments at the Site vicinity range from approximately 16 ppm to 650 ppm (Bayne, 1962). Depth to groundwater is impacted by recovery wells, which run 24 hours per day, 7 days per week. The shallowest depth to groundwater recorded at the Site between 1999 and 2013 ranges from less than 10 to more than 20 feet below ground surface (bgs) (Figure 2-1).

Recharge of alluvial aquifers in the region is due mainly to infiltration of precipitation. On an intermittent basis, the Arkansas and Walnut Rivers contribute to alluvial aquifer recharge (Bayne, 1962). During flood conditions, when river water elevations are above the level of the groundwater in the aquifer, movement is in the direction of the aquifer (away from the stream) and aquifer recharge occurs. Regionally, discharge of groundwater usually occurs by flow to streams and rivers, and by evapotranspiration, pumping, and leakage into hydraulically connected aquifers.

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2.2.4 Regional Surface Water

The Site is located between the Arkansas and Walnut Rivers upstream of the confluence of the two rivers. The Arkansas River flows southeasterly through Arkansas City then meanders to the northeast where it merges with the south-southeast flowing Walnut River. The two rivers are principal waterways in Cowley County.

Portions of the Site are located within the 100-year flood plain of the Walnut River and the Arkansas River. The maximum peak flow recorded on the Arkansas River is 103,000 cubic feet per second (cfs) on June 10, 1923 and on the Walnut River, the maximum peak flow recorded is 105,000 cfs on April 23, 1944. The maximum peak flow periods of record for the Arkansas and Walnut Rivers are 1903-2013 and 1898-2013, respectively.

Mean daily flows from the Arkansas City gauging station on the Arkansas River and the Walnut River for 1960 through 2010 were obtained from the USGS. For the Arkansas River at Arkansas City (USGS Station 07146500) the mean of the annual maximum mean daily flow was 29,161 cfs. The month when the annual maximum occurred was highly variable from year to year, generally occurring from March through June, or from September through November. The mean of the annual minimum mean daily flow at this station and for this period was 317 cfs. The month when the annual minimum occurred was generally either January or from August through October.

For the Walnut River at Winfield (USGS Station 07147800) the mean of the annual maximum mean daily flow for this period was 24,088 cfs. The month when the annual maximum occurred was again highly variable but most often from April through June, or in November. The mean of the annual minimum mean daily flow for the Walnut River at Winfield for this period was 56 cfs. The month when the annual minimum occurred was most often August, September, or October.

2.2.5 Climate

According to U.S. Army Corps of Engineers (USACE), December 1984, the climate of Cowley County, Kansas is normal for middle latitude, interior continental areas. It is characterized by large variations in annual and daily temperatures, long, hot summers and cold, short winters. The average daily temperature in the winter is 36.6°F. The recorded high and low temperatures for Cowley County are 118°F on August 12, 1936 and -27°F on February 13, 1905, respectively.

Long-term precipitation data are currently available for the 1971-2000 30-year climate normals period. Precipitation in Cowley County is highest during the spring and summer (April-September). Seventy-two percent of the average annual precipitation of 36.7 inches occurs during late evening or nighttime thunderstorms. Ten to eleven inches of the annual precipitation occurs as snowfall.

Occasionally, tornadoes and severe thunderstorms occur within Cowley County. Storms are usually localized in extent and are of short duration. Crop damage by hail is not as extensive in Cowley County as in areas further west.

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The closest location recording data on wind speed and direction is Wichita, Kansas. The wind rose (MWH, 2011) for Wichita, Kansas (2000-2009) indicates that the prevailing wind is from the south at an annual mean speed of 13 mph. The secondary prevailing wind direction is from the north.

The average evaporation from March to November for the closest station (Elk City Lake Station, located approximately 55 miles east-northeast of the facility) was 51 inches per year, based on data from 1960 to 1992 (available period of record). No evaporation data is recorded for Arkansas City, Kansas.

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3.0 DATA SUMMARY AND EVALUATION

A summary of the available surface water and sediment characterization data for the Site is presented in Section 3.1, and recommendations for additional data collection are presented in Section 3.2.

3.1 DATA SUMMARY

The 1990 RFI was conducted to address potential contamination in soil, groundwater, surface water, and sediment at the Site (RSA, 1992). Additional delineation was conducted during the Phase II RFI in 1999 (Earth Tech, 2000). Soil and groundwater data are described in the HHRA Work Plan for those media (MWH, 2014); surface water and sediment data are described in the following sections.

3.1.1 Surface Water

Surface water data collected during the 1990 RFI include one sample each from SWMUs 9 and 11, and river locations upstream of the Site, near the NPDES outfall, and at the downstream corner of the Site (Figure 2-2). Samples from the Evaporation Ponds in 1990 were submitted for a limited analysis suite; detected chemicals include ethylbenzene, toluene, and xylenes in Evaporation Pond No. 1 and chromium and lead in Evaporation Pond No. 3 (Table 3-1). Compounds detected in samples collected from the Walnut River in 1990 at upstream, outfall, and downstream locations include several metals and volatile organic compounds (VOCs), including BTEX (Table 3-2).

Surface water sampling during the Phase II RFI was limited to off-Site samples collected from the Walnut River upstream of the Site (SW-1), at the NPDES outfall (SW-2), and downstream (SW-3) at the eastern corner of the CDL (Figure 2-2). Metals and cyanide were detected in samples from upstream of the Site, at the outfall, and at the downstream corner of the Site. One VOC, chloroform, was detected in one sample from the upstream location, and two additional VOCs, 2-butanone and trichloroethene were detected in two different samples from the downstream location (Table 3-2).

3.1.2 Sediment

Sediment samples collected during the 1989 investigation include discrete and composite sediment samples from SWMUs 9, 10, and 11 and sediment samples from the Walnut River upstream of the Site, at the NPDES outfall, and downstream of the Site. Sediment samples collected from the Evaporation Ponds No. 1 through No. 3 in 1990 were submitted for a limited suite of analyses, including chromium, lead, BTEX, and several PAHs. All of these analytes were detected in at least one Evaporation Pond. Barium, chromium, lead, di-n-butylphthalate, and xylenes were detected at all three river sample locations in 1989; benzene and xylene were detected at the outfall sample location, and chlorobenzene, ethylbenzene, and xylene were detected at the upstream sample location. Detection limits for some organic compounds were elevated in these 1989 and 1990 data (Table 3-4).

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During the Phase II RFI, three samples were collected from the top six inches of sediment in each of SWMUs 9, 10, and 11. Each sample was submitted for VOC and SVOC analyses based on field screening with an organic vapor analyzer. The sample with the highest field screening photoionization detector (PID) result was selected for analysis. The sample submitted for metals analysis was a composite of three discrete samples from within each SWMU. Detected analytes include metals, VOCs, and SVOCs, including PAHs (Table 3-3). Walnut River sediment sampling was not included in the Phase II RFI.

3.2 DATA EVALUATION / DATA GAP RECOMMENDATIONS

Minimum criteria for analytical results to be usable for risk assessment are presented in EPA (1992a). These include requirements for complete data reporting (i.e., sample location, field data and meteorological data), and complete data documentation (i.e., chain of custody records, standard operating procedures, and field notes). The sample collection, preparation, and analytical methods should appropriately identify the constituent form or species; and the specified sample detection limit should be at or below a concentration that is associated with toxicologically relevant levels (e.g., published risk-based screening levels or action levels). Non-detect results with reporting limits greater than the toxicologically relevant levels are not suitable for risk assessment; the significance of any analytical detection limits greater than such criteria will be evaluated on a case-by-case basis and will be described in the Uncertainty Analysis section of the baseline HHRA Report for surface water and sediment. EPA (1992a) further requires that data quality indicators be included in the sampling plan at a level sufficient to determine data usability. According to USEPA (1989a), only data collected and analyzed at a quality control (QC) level equivalent to USEPA Level III or higher (USEPA, 1988), meets appropriate usability criteria for evaluation in a quantitative HHRA. USEPA Level III data provide the following:

- Low detection limits
- A wide range of calibrated analyses
- Matrix recovery information
- Laboratory process control information
- Known precision and accuracy

In addition to the data quality objectives listed above, it is necessary to obtain a sufficient quantity of data to estimate potential exposure concentrations. The number of samples required to adequately characterize an exposure area depends on the size of the area and the heterogeneity of the media and potential contamination. The usability of the existing surface water and sediment data for the Site, and requirements for additional data, are described briefly below.

3.2.1 Surface Water

Evaporation Ponds 1, 2, and 3 (SWMUs 9, 10, and 11) and Stormwater Pond (SWMU 23)

Surface water sampling data for the evaporation ponds and the stormwater pond are only available for a limited analyte list and for one sample each from SWMUs 9 and 11, and these data are more than 20 years old. Historic data indicate that potentially Site-related chemicals

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have been detected, but do not meet the data quality requirements for inclusion in the HHRA for surface water and sediment. Therefore, surface water in SWMUs 9, 10, 11, and 23 should be sampled. The stormwater ponds are dry most of the year, so sampling will occur in the winter. Total surface area for the ponds is between 7,500 and 10,000 square feet, however, surface area of the actual water in the ponds may be less. A minimum of one location will be sampled at two to three depths (i.e., surface, midway in the water column, and bottom of the pond), depending on the depth of the pond. Samples will be analyzed for metals, VOCs, and SVOCs. Details of the sample locations, sampling procedures and analytical methods will be described in the Surface Water and Sediment Investigation Work Plan.

Walnut River Surface Water

Surface water samples were collected from three locations in the 1990 Surface Water and Sediment Characterization and the 1999 Phase II RFI; upstream of the Site, at the NPDES outfall and at the downstream corner of the Site. Sampling results from both 1989 and 1999 did not indicate that potential contaminants were present at higher concentrations at the NPDES outfall or down gradient of the Site, compared with upgradient sample results. Additionally, attributing detected concentrations of analytes in surface water in the Walnut River, even during low flow conditions, to historic sediment impacts associated with the Site will be difficult. At the request of the Agencies, however, surface water samples will be collected from the Walnut River. Historic surface water sampling data from the Walnut River do not meet the data quality requirements for inclusion in the HHRA for surface water and sediment; results from these samples will be replaced by new surface water samples to be collected upstream of the Site, near the NPDES outfall, and downstream of the Site. The surface water samples should be analyzed for metals, VOCs and SVOCs. Details of the sample locations, sampling procedures and analytical methods will be described in the Surface Water and Sediment Investigation Work Plan.

3.2.2 Sediment

Evaporation Ponds 1, 2, and 3 (SWMUs 9, 10, and 11) and Stormwater Pond (SWMU 23)

Sediment data are only available for a few locations from each pond; the data for SWMU 23 consists of the shallow soil results from a soil boring presented in the 1992 Final RFI Report. Data from these samples do not meet the data quality requirements for inclusion in the HHRA for surface water and sediment; therefore, sediment sampling is recommended for all ponds. Composite samples will be collected according to guidelines for ponds 10,000 square feet and under from KDHE (1996). Five composite samples will be collected from each pond in order to characterize current and future exposures to surface sediment, and future exposures to deeper sediment during potential excavation. Composite samples will be collected from the pond bottom from 0-2 inches and 0-2 feet below ground surface. The pond bottom composite samples will include discrete samples from each of the four quadrants in the pond bottom. One composite sample will include four discrete samples from the pond sides, and two composite samples will include discrete samples from the pond inlets and outlets from 0-2 inches bgs and 0-2 feet bgs. Samples will be analyzed for metals, VOCs, and SVOCs. Details of the sample locations, sampling handling procedures, including sample compositing and selection of a representative

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sample for VOC analysis, and analytical methods will be described in the Surface Water and Sediment Investigation Work Plan; samples for VOC analysis will not be composited.

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Walnut River Sediment

Off-Site sediment data from locations upstream, at the NPDES outfall, and downstream of the Site are available from 1989 only. These sample results include few detections and no clear pattern to indicate Site-related impacts. Additionally, access to sediment at the location of historically observed hydrocarbon seeps are no longer available due to river realignment and raising of the levee by the USACE. In 1998 and 1999 remedial measures were implemented in the areas where hydrocarbon seeps were observed. These remedial measures were implemented before the USACE river realignment and levee improvements. These remedies subsequently stopped the hydrocarbon seeps. Historic sediment sampling results do not meet the data quality requirements for inclusion in the HHRA for surface water and sediment and are not applicable to current conditions, and therefore these data are included for historical reference only.

To verify the current river sediment quality, sediment samples will be collected from the Walnut River upstream of the Site, at the NPDES outfall, and downstream of the site. The sediment samples should be analyzed for metals, VOCs and SVOCs. Details of the sample locations, sampling procedures and analytical methods will be described in the Surface Water and Sediment Investigation Work Plan.

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4.0 HUMAN HEALTH RISK ASSESSMENT APPROACH

The methods to be used in the baseline HHRA for surface water and sediment are described in this section.

4.1 CONCEPTUAL SITE MODEL

The HHRA begins with the development of a site-specific conceptual site model (CSM). The site-specific CSM includes the identification of sources of contaminated media and constituents of potential concern (COPCs), evaluation of contaminant fate and transport pathways, potentially exposed populations, and potentially complete exposure pathways between contaminated media and receptors.

The following subsections describe methods to be used in the identification of medium-specific COPCs and the development of a site-specific CSM for the Site.

4.1.1 Contaminated Media and COPC Selection

Impacted media at the Site include surface and subsurface soil, groundwater, surface water and sediment. Soil and groundwater are evaluated in a separate HHRA (MWH, 2014). Although exposures associated with surface water and sediment are different than standard scenarios for soil or potable groundwater, identification of COPCs in surface water and sediment will be conducted in accordance with USEPA guidance. All analytical results (i.e., maximum detected concentration for detected analytes and maximum reporting limit for non-detect analytes) will be screened against the most current version of the USEPA's biannually updated Regional Screening Levels (RSLs) (USEPA, 2014a) for tap water and industrial soil exposures. According to USEPA (2009a), when more than one constituent is present in a Site medium, it is appropriate to consider the potential for cumulative effects from all detected constituents in that medium. This is because a constituent may be present at a maximum concentration that is lower than its respective screening level, but still contribute to a *cumulative* carcinogenic risk or noncarcinogenic hazard index (HI) that is greater than acceptable risk management criteria due to impacts of multiple constituents on a given toxicological endpoint. Cumulative effects screening is achieved by utilizing the version of the RSL Table developed for a target hazard quotient of 0.1 and a target risk of $1x10^{-6}$. The target hazard quotient of 0.1 is a factor of 10 less than the KDHE point of departure of 1; the cumulative lifetime cancer risk of 1×10^{-6} is already 10 times lower than the KDHE point of departure of 1×10^{-5}, and is therefore adequate for cumulative effects screening.

Analytes in surface water or sediment that are not related to refinery operations with a maximum detected concentration or an MDL or MRL below their respective screening level will be excluded from further evaluation in the baseline HHRA. Results for non-detect analytes with a MDL or MRL greater than their respective screening level will be evaluated on an analyte-specific basis. Analytes that are related to Site operations will be evaluated in the baseline HHRA even if they were not detected in surface water or sediment at concentrations greater than their respective screening levels.

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Proposed surface water and sediment COPC screening values for use at the Site are presented in Table 3-1 through Table 3-4, respectively; these values are based on the current version of the RSLs (USEPA, 2014a) and will be updated for the HHRA Report, as appropriate. Formal COPC selection based on current RSLs will be presented in the HHRA Report, following additional characterization work.

4.1.2 Human Health CSM

The CSM describes the nature of contaminant sources, current and future human receptors that may be present and the potential for complete exposure pathways between contaminant sources and receptors (USEPA, 1989a; 1989b). The CSM for current and hypothetical future human receptors is depicted graphically in Figure 4-1 and described below.

4.1.2.1 Contamination Sources and Transport Pathways

Sources of soil contamination at the Site include historic spills and leaks from ASTs, process equipment, and SWMUs in the Process Area, leaching of metals and petroleum materials from decommissioned equipment in the Junk Storage Area, releases from SWMUs in the Construction Debris Landfill, and releases associated with tanks and SWMUs in the Former Tank Farm. Contaminants in soil may have volatilized to ambient air or been transported as windblown dust to other land or water areas. Site-related contaminants in soil that have infiltrated over time to the water table could seep into construction or utility trenches or discharge to off-Site surface water. Treated groundwater is discharged in to active on-Site treatment ponds and the Walnut River.

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4.1.2.2 Potential Receptors

Current use of the property is limited to a small asphalt terminal consisting of a loading area and three in service ASTs. Additionally, the Site has a security fence and closed gate. It is assumed that all parcels will be redeveloped for commercial or industrial use, consistent with current land use and zoning. It is further assumed that agricultural land use or other growth of edible plants for human consumption will be prohibited. These assumptions will be supported by future land use controls (LUCs) and/or deed restrictions, as necessary.

The Site is located adjacent to a residential area, a sports park, the Kaw Wildlife Area, and the Arkansas and Walnut Rivers. However, transport of contaminants as windblown dust is likely to be minimal, and treated water discharged to the Walnut River meets NPDES requirements. Therefore, the only likely route for off-Site transport is with groundwater discharge to the Walnut River in the absence of the groundwater capture and treatment system. Impacted off-Site sediment from historic discharges to the Walnut River prior to installation of the treatment system has been covered or separated from the current river channel by modifications to the Army Corps' levee.

Potentially exposed receptors include current and future on-Site commercial or industrial workers (i.e., existing Site MRP employees, and future commercial/industrial workers following redevelopment of the Site), future construction or utility workers, current and future on-Site trespassers, and current and future off-Site recreational users of the Walnut River. Off-Site

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receptors are not likely to be exposed to Site-related contamination, due to the limited potential for off-Site transport described above; however, exposure of current and future recreational users will conservatively be evaluated. Minimal work occurs at or near the stormwater ponds currently, and therefore exposure assumptions associated with future commercial or industrial workers will be protective of current commercial or industrial workers. Additionally, the evaluation of future commercial/industrial workers will be protective of any on-Site trespassers. Exposures associated with future on-Site construction work are likely to be protective of any minimal utility work that would occur in or near the stormwater ponds and the exposure parameters for the future construction/utility worker receptor will be based on hypothetical exposures that might occur during construction. Therefore, the three receptors to be quantitatively evaluated in the HHRA for surface water and sediment are future on-Site outdoor commercial or industrial workers, future on-Site construction or utility workers, and current / future off-Site recreational users.

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Potentially Complete Exposure Pathways for On-Site Receptors

Current/future commercial or industrial workers and future construction or utility workers may be exposed to contaminated surface water via incidental ingestion and dermal contact. Concentrations of surface water derived volatile compounds in outdoor ambient air are likely to be insignificant, and therefore this exposure pathway is complete but insignificant. As noted previously, the stormwater ponds are only seasonally wet; therefore the exposure frequency for surface water will be limited to a fraction of the year. Exposure to sediment contamination may occur via incidental ingestion of, and dermal contact with contaminated sediment, and, during period when the ponds are dry, inhalation of volatile contaminants in sediment and nonvolatile contaminants adsorbed to wind-blown dust. Current and future workers at a commercial or industrial site are potentially exposed to media in stormwater ponds while mowing, cutting vegetation, or otherwise maintaining the ponds perimeter. Such grounds keeping work currently occurs once per week during the months of April through September, and would result in exposure of Site workers to surface sediment (i.e., the top two inches bgs). Future construction and utility workers are potentially exposed to media in stormwater ponds while expanding or otherwise modifying the ponds, or in the process of redeveloping the location of a former pond. Although this work would likely take place when the pond was dry, surface water exposure is conservatively evaluated for this receptor. Future on-Site construction/utility workers are assumed to be exposed to sediment from ground surface to two feet bgs. Deeper excavation during construction is not expected because the bottoms of the stormwater ponds are already close to the water table.

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Potentially Complete Exposure Pathways for Off-Site Receptors

Off-Site receptors exposed to surface water and sediment in the Walnut River include people boating, swimming, and fishing. The portion of the Walnut River adjacent to the Site is not developed for swimmers or non-fishing recreational boaters; therefore the most highly exposed potential off-Site receptor is a person recreationally fishing. This receptor might be incidentally exposed to surface water, surface sediment from zero to two inches bgs, and fish that have accumulated contaminants from sediment and surface water. Concentrations of surface water derived volatile compounds in outdoor ambient air are likely to be insignificant, and therefore

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this exposure pathway is complete but insignificant. Inhalation of sediment derived volatile constituents and non-volatile constituents adsorbed to dust is an incomplete pathway for the off-Site recreational receptor because potentially contaminated sediment is continually inundated. Although wading in the portion of the Walnut River located adjacent to the Site is unlikely, exposure parameters for the recreational receptor will conservatively assume that this receptor wades in to the river barefoot while fishing. Additionally, because child incidental ingestion rates and soil adherence factors result in higher doses than adult exposure rates, noncancer effects characterization will be based on an adolescent (i.e., 6 to 11 year old) recreational receptor. Cancer risk estimates are based on cumulative exposure over the entire lifetime, and therefore the dose estimates for carcinogenic chemicals will be based on a composite adolescent and adult recreational receptor.

4.2 BASELINE HUMAN HEALTH RISK ASSESSMENT METHODS

The baseline HHRA for the Site will be performed in accordance with the following USEPA guidance documents:

- Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual, Part A (USEPA, 1989a).
- Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual, Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments (USEPA, 2001).
- Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988).
- Final Exposure Assessment Guidelines (USEPA, 1992b).
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002).
- Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004).
- Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009a).
- Exposure Factors Handbook: 2011 Edition (USEPA, 2011a).

The general framework for conducting baseline HHRAs is provided in USEPA's *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part A. Baseline Risk Assessment* (USEPA, 1989a). Consistent with these guidance documents, the baseline HHRA consists of the following five steps:

1. Exposure assessment
2. Data evaluation and exposure quantification
3. Toxicity assessment
4. Risk characterization
5. Uncertainty analysis

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4.2.1 Exposure Assessment

The exposure assessment begins with development of a site-specific CSM; the human health CSM for the Site was described in Section 4.1.

Potential human receptors to be evaluated in the HHRA for surface water and sediment are future industrial or commercial workers, future utility or construction workers, and current and future off-Site recreational users, as described in Section 4.1.2.2. Potentially complete exposure pathways for these receptors are presented graphically in Figure 4-1.

4.2.2 Data Evaluation and Exposure Quantification

Prior to use in risk and hazard quantification, site data are evaluated for quality and usability according to the methods in Section 3.2. Data of adequate quality are screened as described in Section 4.1.1 to identify COPCs.

Potential exposures and risks associated with the complete exposure pathways identified in Section 4.1.2.2 will be quantified according to the procedures described below. Methods to be used in the derivation of exposure point concentrations (EPCs), and procedures for quantifying theoretical exposure doses, are described in the following subsections. As described previously, likely future land uses for the Site with the highest potential for human exposure include industrial facilities or business parks where significant portions of the properties are unpaved and left barren and/or landscaped. Due to compaction of Site soils, continued use of the existing retention basins to contain stormwater runoff is expected in a future industrial or commercial scenario. Additionally, the surface water stage of the groundwater treatment system is expected to remain unchanged in the near future.

Surface water and sediment exposures will be quantified separately for each stormwater retention pond. As described in Section 3.2, the number of samples used to calculate surface water EPCs will be determined based on the estimated volume and heterogeneity of the water in the pond. Sediment EPCs will be based on results of three composite samples from each pond. Sediment sample locations will not be limited to the current wetted area of the pond at the time of sampling, but instead will encompass all potentially contaminated material.

4.2.2.1 Calculating Exposure Doses

Exposure doses will be calculated according to methods and intake equations presented in USEPA's *Risk Assessment Guidance for Superfund* (RAGS; USEPA, 1989a). Equations for quantifying incidental ingestion, dermal contact, and inhalation exposures to COPCs in soil are presented below. Exposure parameters used in dose modeling are presented in Table 4-1. For the current/future recreational receptor exposed to carcinogenic chemicals, the exposure dose equations are modified to include an age-adjusted factor that combines the dose assumptions for adolescent and adult receptors in to a single factor that incorporates age specific exposure parameters such as body weight, ingestion rate, and exposure duration. As described in Section 4.1.2.2, a child or adolescent is the most conservative receptor for evaluation of the effects of non-carcinogenic chemicals, and therefore an age adjusted intake is not used for these chemicals.

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The composite dose equation and age-adjusted factor for current/future recreational receptors is listed after the single-age dose equation for each medium.

Incidental Ingestion of Sediment

$$\text{Ingestion Intake for Sediment}\left(\frac{\text{mg}}{\text{kg} \times \text{day}}\right) = \frac{\text{CS} \times \text{IR} \times \text{CF} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Where:

CS	=	concentration in sediment (milligrams per kilogram [mg/kg])
IR	=	ingestion rate (mg sediment/day)
CF	=	conversion factor (10^{-6} kilograms per milligram [kg/mg])
EF	=	exposure frequency (days/year)
ED	=	exposure duration (years)
BW	=	body weight (kilogram [kg])
AT	=	averaging time (period over which exposure is averaged – days)

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Incidental Ingestion of Sediment for Composite Adolescent and Adult Receptors

$$\text{Composite Ingestion Intake for Sediment}\left(\frac{\text{mg}}{\text{kg} \times \text{day}}\right) = \frac{\text{CS} \times \text{IF}_{sed} \times \text{CF}}{\text{AT}}$$

Where:

$$\text{IF}_{sed}\left(\frac{\text{mg}}{\text{kg}}\right) = \frac{\text{IR}_{adolescent} \times \text{ED}_{adolescent} \times EF_{adolescent}}{BW_{adolescent}} + \frac{\text{IR}_{adult} \times \text{ED}_{adult} \times EF_{adult}}{BW_{adult}}$$

and

CS	=	concentration in sediment (mg/kg)
IF_{sed}	=	age adjusted sediment ingestion factor (mg/kg)
CF	=	conversion factor (10^{-6} kg/mg)
AT	=	averaging time (period over which exposure is averaged – days)
$\text{IR}_{adolescent}$	=	adolescent ingestion rate (mg sediment/day)
IR_{adult}	=	adult ingestion rate (mg sediment/day)
$\text{ED}_{adolescent}$	=	adolescent exposure duration (years)
ED_{adult}	=	adult exposure duration (years)
$\text{EF}_{adolescent}$	=	adolescent exposure frequency (days/year)
EF_{adult}	=	adult exposure frequency (days/year)
$\text{BW}_{adolescent}$	=	adolescent body weight (kg)
BW_{adult}	=	adult body weight (kg)

As described in Section 4.2.3.1 below, if arsenic is identified as a COPC, the oral dose will be adjusted by the relative bioavailability (RBA) of 60% for arsenic.

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Dermal Contact with Sediment

$$\text{Dermal Contact with Sediment}\left(\frac{mg}{kg \times day}\right) = \frac{CS \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Where:

CS = concentration in sediment (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
SA = skin surface area exposed (square centimeters [cm^2])
AF = adherence factor of sediment (milligrams per square centimeter per day [mg/cm^2-day])
ABS = skin absorption factor (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (period over which exposure is averaged – days)

Dermal Contact with Sediment for Composite Adolescent and Adult Receptors

$$\text{Composite Dermal Contact with Sediment}\left(\frac{mg}{kg \times day}\right) = \frac{CS \times DF_{sed} \times ABS \times CF}{AT}$$

Where:

$$DF_{sed}\left(\frac{mg}{kg}\right) = \frac{AF_{adolescent} \times SA_{adolescent} \times ED_{adolescent} \times EF_{adolescent}}{BW_{adolescent}} + \frac{AF_{adult} \times SA_{adult} \times ED_{adult} \times EF_{adult}}{BW_{adult}}$$

and

CS = concentration in sediment (mg/kg)
DF_{sed} = age adjusted sediment dermal factor (mg/kg)
ABS = skin absorption factor (unitless)
CF = conversion factor (10-6 kg/mg)
AT = averaging time (period over which exposure is averaged – days)
$AF_{adolescent}$ = adolescent adherence factor for sediment (mg/cm^2-day)
AF_{adult} = adult adherence factor for sediment (mg/cm^2-day)
$SA_{adolescent}$ = adolescent skin surface area exposed (cm^2)
SA_{adult} = adult skin surface area exposed (cm^2)
$ED_{adolescent}$ = adolescent exposure duration (years)
ED_{adult} = adult exposure duration (years)
$EF_{adolescent}$ = adolescent exposure frequency (days/year)
EF_{adult} = adult exposure frequency (days/year)
$BW_{adolescent}$ = adolescent body weight (kg)
BW_{adult} = adult body weight (kg)

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Incidental Ingestion of Surface Water:

$$\text{Incidental Ingestion Intake for Surface Water}\left(\frac{mg}{kg \times day}\right) = \frac{CW \times IR \times CF \times ET \times EF \times ED}{BW \times AT}$$

Where:

CW = concentration in water (mg/L)
IR = ingestion rate (milliliters per hour [mL/hour])
CF = conversion factor (L/mL)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (period over which exposure is averaged – days)

Incidental Ingestion of Surface Water for Composite Adolescent and Adult Receptors

$$\text{Composite Ingestion Intake for Surface Water}\left(\frac{mg}{kg \times day}\right) = \frac{CW \times IF_{sw} \times CF}{AT}$$

Where:

$$IF_{sw}\left(\frac{mL}{kg}\right) = \frac{IR_{adolescent} \times ED_{adolescent} \times EF_{adolescent} \times ET_{adolescent}}{BW_{adolescent}} + \frac{IR_{adult} \times ED_{adult} \times EF_{adult} \times ET_{adult}}{BW_{adult}}$$

and

CW = concentration in surface water (mg/L)
IF_{sw} = age adjusted surface water ingestion factor (mL/kg)
CF = conversion factor (10^{-6} L/mL)
AT = averaging time (period over which exposure is averaged – days)
$IR_{adolescent}$ = adolescent ingestion rate (mL/hour)
IR_{adult} = adult ingestion rate (mL/hour)
$ED_{adolescent}$ = adolescent exposure duration (years)
ED_{adult} = adult exposure duration (years)
$EF_{adolescent}$ = adolescent exposure frequency (days/year)
EF_{adult} = adult exposure frequency (days/year)
$ET_{adolescent}$ = adolescent exposure time (hours/day)
ET_{adult} = adult exposure time (hours/day)
$BW_{adolescent}$ = adolescent body weight (kg)
BW_{adult} = adult body weight (kg)

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Dermal Contact with Surface Water:

The dermally absorbed dose for some chemicals is not high enough to warrant inclusion in the total dose calculation. Organic and inorganic COPCs in surface water will be screened according to Exhibit B-3 and Exhibit B-4, respectively, in USEPA (2004).

$$\text{Dermal Contact with Surface Water}\left(\frac{\text{mg}}{\text{kg} \times \text{day}}\right) = \frac{CW \times CF \times ED \times EF \times ET \times SA \times Kp}{BW \times AT}$$

Where:

CW = concentration in surface water (mg/L)
CF = conversion factor (10-3 L/cm3)
ED = exposure duration (years)
EF = exposure frequency (days/year)
ET = dermal exposure time (hours/day)
SA = skin surface area exposed (cm2)
Kp = dermal permeability constant (cm/hour)
BW = body weight (kg)
AT = averaging time (period over which exposure is averaged – days)

Dermal Contact with Surface Water for Composite Adolescent and Adult Receptors

$$\text{Composite Dermal Contact with Surface Water}\left(\frac{\text{mg}}{\text{kg} \times \text{day}}\right) = \frac{CW \times CF \times DF_{sw} \times ET \times Kp}{AT}$$

Where:

$$DF_{sw}\left(\frac{\text{cm}^2 \times \text{day}}{\text{kg}}\right) = \frac{SA_{adolescent} \times ED_{adolescent} \times EF_{adolescent}}{BW_{adolescent}} + \frac{SA_{adult} \times ED_{adult} \times EF_{adult}}{BW_{adult}}$$

and

CW = concentration in surface water (mg/L)
CF = conversion factor (10^{-3} L/cm^3)
DF_{sw} = age adjusted surface water dermal factor (cm^2 x day/kg)
ET = dermal exposure time (hours/day)
Kp = dermal permeability constant (cm/hour)
AT = averaging time (period over which exposure is averaged – days)
$SA_{adolescent}$ = adolescent skin surface area exposed (cm^2)
SA_{adult} = adult skin surface area exposed (cm^2)
$ED_{adolescent}$ = adolescent exposure duration (years)
ED_{adult} = adult exposure duration (years)
$EF_{adolescent}$ = adolescent exposure frequency (days/year)
EF_{adult} = adult exposure frequency (days/year)
$BW_{adolescent}$ = adolescent body weight (kg)
BW_{adult} = adult body weight (kg)

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Inhalation of Ambient Air:

$$\text{Noncancer Inhalation of COPCs in Dry Sediment}\left(\frac{mg}{m^3}\right) = \frac{CS \times (\frac{1}{PEF} \text{ or } \frac{1}{VF}) \times EF \times ED \times ET}{AT}$$

Where:

- CS = concentration in sediment (mg/kg)
- PEF = particulate emission factor (m^3/kg)
- VF = volatilization factor (m^3/kg)
- EF = exposure frequency (days/year)
- ED = exposure duration (years)
- ET = exposure time (unitless; hours per 24 hour day)
- AT = averaging time (period over which exposure is averaged – days)

The inhalation exposure concentration for carcinogenic COPCs will include an additional conversion factor of 1,000 micrograms (µg) per milligram, such that the units of the exposure concentration are µg/m^3. Inhalation pathways are incomplete for current/future off-Site recreational receptors, and therefore no composite inhalation dose equation is necessary.

Modeling parameters for Lincoln Nebraska presented in Appendix D of USEPA (2002) and pond-specific areas will be used to calculate pond-specific PEFs for calculation inhalation exposure concentrations for future commercial or industrial workers. The pond-specific PEFs used to calculate inhalation exposures for future construction or utility workers will be calculated according to the pond-specific area, and models and parameters presented in Appendix E of USEPA (2002).

Ingestion of Fish:

$$\text{Ingestion of Fish}\left(\frac{mg}{kg \times day}\right) = \frac{C_{fish} \times IR \times ED \times EF \times CF}{BW \times AT}$$

Where:

- C_{fish} = concentration of contaminant in fish (mg/kg)
- IR = fish ingestion rate (mg / day)
- CF = conversion factor (10^{-6} kg/mg)
- ED = exposure duration (years)
- EF = exposure frequency (days/year)
- BW = body weight (kg)
- AT = averaging time (period over which exposure is averaged – days)

Fish tissue concentration will be modeled from sediment data using bioaccumulation factors.

Ingestion of Fish for Composite Adolescent and Adult Receptors

$$\text{Composite Ingestion Intake for Fish}\left(\frac{mg}{kg \times day}\right) = \frac{C_{fish} \times IF_{fish} \times CF}{AT}$$

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Noncancer Inhalation of Volatile COPCs in Surface \

$\frac{CW \times ED \times EF \times K}{AT}$¶

¶

Where ¶

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CW = Concentration in surface water (mg/L)¶
ED = Exposure duration (years)¶
EF = Exposure frequency (days/year)¶
K = Volatility factor (L/m3)¶
AT = Averaging time (period over which exposure is averaged – days)¶

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Where:

$$IF_{fish}\left(\frac{mg}{kg}\right) = \frac{IR_{adolescent} \times ED_{adolescent} \times EF_{adolescent}}{BW_{adolescent}} + \frac{IR_{adult} \times ED_{adult} \times EF_{adult}}{BW_{adult}}$$

and

C_{fish} = concentration in fish (mg/kg)
IF_{fish} = age adjusted fish ingestion factor (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
AT = averaging time (period over which exposure is averaged – days)
$IR_{adolescent}$ = adolescent ingestion rate (L /day)
IR_{adult} = adult ingestion rate (L /day)
$ED_{adolescent}$ = adolescent exposure duration (years)
ED_{adult} = adult exposure duration (years)
$EF_{adolescent}$ = adolescent exposure frequency (days/year)
EF_{adult} = adult exposure frequency (days/year)
$BW_{adolescent}$ = adolescent body weight (kg)
BW_{adult} = adult body weight (kg)

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4.2.3 Toxicity Assessment

The human health toxicity assessment will be performed in accordance with EPA Guidance (USEPA, 1989a). The primary sources of toxicity values to be used in the baseline HHRA will be follows:

- Integrated Risk Information System (IRIS) Database (USEPA, 2014b).
- USEPA RSL Table, May, 2014 (USEPA, 2014a).
- Provisional Peer Reviewed Toxicity Values (PPRTV) (USEPA, 2014d).
- Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997a).
- Other USEPA documents, as applicable.
- California Environmental Protection Agency Toxicity Criteria Database (OEHHA, 2014).

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4.2.3.1 Constituent-Specific Assumptions

Dermal Toxicity

Although the USEPA has developed toxicity criteria for the oral and inhalation routes of exposure, toxicity criteria for the dermal route of exposure have not been developed. USEPA has proposed a method for extrapolating oral toxicity criteria to the dermal route in *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (USEPA, 2004). This USEPA guidance states that the adjustment of the oral toxicity factor for dermal exposures is necessary only when the oral-gastrointestinal absorption efficiency of the constituent of interest is less than 50 percent (due to the variability inherent in absorption studies).

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Adjustment of oral toxicity criteria to derive dermal reference doses (RfDs) and cancer slope factors (CSFs) will be conducted as follows:

$$\text{Dermal RfD} = \text{Oral RfD} \times ABS_{GI}$$
$$\text{Dermal CSF} = \text{Oral CSF}/ABS_{GI}$$

Where:

ABS_{GI} = oral absorption efficiency
CSF = cancer slope factor
RfD = reference dose

For constituents lacking an oral-gastrointestinal absorption efficiency value, the oral absorption efficiency is assumed to be 100 percent and the oral RfD or CSF will be used to estimate toxicity via the dermal route.

Lead Toxicity

Cause-and-effect relationships in humans have been correlated with concentrations of lead in blood. Therefore, at sites where lead is identified as a COPC, the preferred risk assessment approach is the estimation of human blood-lead concentrations associated with an exposure situation. If lead is identified as a COPC at the Site, the Adult Lead Model (USEPA, 2009b) will be used to predict blood-lead levels for future commercial or industrial and utility or construction workers exposed to lead in soil.

Arsenic Bioavailability

The USEPA has established a RBA of 60% for arsenic in soil relative to arsenic in water to account for differences in absorption between the readily soluble forms of the chemical ingested with water and the chemical ingested with site media (USEPA, 2012). The reduced dose of arsenic resulting from soil exposures compared to water exposures does not affect the derived oral toxicity values for arsenic, but will be applied to the calculated dose from soil ingestion.

4.2.4 Risk Characterization

Risk characterization integrates the results of exposure and toxicity assessments to derive a quantitative evaluation of potential risks to current and future human receptors. Risk of developing cancer and the potential for noncancer effects are quantified separately by calculating an incremental lifetime cancer risk (ILCR) and hazard quotient (HQ), respectively, as described below.

Analyte-specific cancer risk estimates will be calculated as the sum of all applicable individual pathways for each receptor. The pathway and analyte specific risk is equal to the product of the dose and the cancer toxicity value (USEPA, 1989a):

$$\text{ILCR} = \text{Dose [or concentration]} \times \text{CSF [or IUR]}$$

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Where:

ILCR = incremental lifetime carcinogenic risk (unitless)
CSF = carcinogenic slope factor $(\text{mg/kg-day})^{-1}$
IUR = inhalation unit risk $(\mu g/m^3)^{-1}$
Concentration = exposure concentration $(\mu g/m^3)$
Dose = exposure dose (mg/kg-day)

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Analyte-specific non-cancer hazard estimates will be calculated as the sum of all applicable individual pathways for each receptor. The pathway and analyte specific hazard is equal to the ratio of the dose to the non-cancer toxicity value (USEPA, 1989a):

$$\text{HQ} = \frac{\text{Dose [or concentration]}}{\text{RfD [or RfC]}}$$

Where:

HQ = hazard quotient (unitless)
Concentration = exposure concentration (mg/m^3)
Dose = exposure dose (mg/kg-day)
RfC = reference concentration (mg/m^3)
RfD = reference dose (mg/kg-day)

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Analyte-specific ILCR and HQ estimates will be summed to cumulative media- and exposure area-specific ILCR and hazard index (HI) estimates for each pond and the Walnut River. Cumulative surface water and sediment ILCR and HI estimates will then be summed for cumulative exposure area-specific cancer risk and noncancer hazard estimates.

The EPA considers a cancer risk between 1×10^{-6} and 1×10^{-4} and a noncancer HI of 1 as the point of departure for making risk management decisions concerning a site. Sites with associated cumulative cancer risk and noncancer HI estimates that exceed these criteria are proposed for further evaluation, or consideration of remedial alternatives. Previous agreement between EPA, KDHE, and MRP has set 1×10^{-5} as the cancer risk point of departure for this Site. Exposure Units with a cumulative cancer risk estimate below 1×10^{-5}, and a noncancer HI of less than 1, may be appropriate for conditional closure.

4.2.5 Uncertainty Analysis

Uncertainties are inherent in the risk assessment process and arise from limitations in the available information, analysis methods, and necessary assumptions. Sources of uncertainty may include chemical characterization information and limitations in the available data, assessment of potential exposures, and modeling of uptake and toxicity. Each of these sources of uncertainty, and any additional Site-specific uncertainties, will be described in the HHRA Report for surface water and sediment.

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Table 3-1
Available Characterization Data for On-Site Surface Water
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	**Screening Level [a]**	**Surface Water Characterization Sample Results (1990) [b]**	
		SWMU 9	**SWMU 11**
Metals			
Chromium	2,200	<5	82
Hexavalent chromium [c]	0.035	-	-
Lead	15	**<3**	**154.3**
Volatile Organic Compounds			
Benzene	0.45	**<1**	**<1**
Ethylbenzene	1.5	1.2	<1
Toluene	110	1.7	<1
Xylene	19	7.2	<1
Semi-volatile Organic Compounds			
Anthracene	180	-	<14
Chrysene	3.4	-	**<4**
Naphthalene	0.17	-	**<36**
Phenanthrene	-	-	**<12**

Notes:
All sample results and screening levels are presented in micrograms per liter (µg/L).

- = not applicable; analysis not performed or screening value not available for this chemical
< = analyte not detected; value shown is the detection limit
SWMU - solid waste management unit
µg/L - micrograms per liter

Bolding of a chemical name indicates that the screening level was exceeded by a detected concentration or detection limit; **bolding** of a value indicates that the screening level was exceeded by that value.

[a] United States Environmental Protection Agency Tap Water Regional Screening Levels (USEPA, 2014a). Screening levels for non-carcinogenic compounds are based on a hazard quotient (HQ) of 0.1.
[b] Results of surface water sampling of on-Site ponds, as reported in the Surface Water and Sediment Characterization Report (Total Petroleum, Inc.) dated 9/4/1990. No additional data have been collected for on-Site surface water.
[c] Speciated chromium analyses were not performed on historic samples; however surface water samples collected for the Human Health Risk Assessment will be analyzed for hexavalent chromium.

Table 3-2
Available Characterization Data for Surface Water in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Surface Water Characterization Sample Results (1990) [b]						Phase II RFI Surface Water Sample Results (1999) [c]					
		Upstream		NPDES Outfall		Downstream		Upstream		NPDES Outfall		Downstream	
		No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result
Metals													
Antimony	0.78	0	**<50**	0	**<50**	0	**<50**	0	**<5**	0	**<5**	0	**<5**
Arsenic	0.052	0	**<10**	0	**<10**	0	**<10**	1	**4.8**	2	**4.8**	3	**4.4**
Barium	380	1	300	2	**400**	2	**400**	3	169	3	166	3	196
Beryllium	2.5	-	-	-	-	-	-	2	0.39	2	0.58	1	0.90
Cadmium	0.92	0	**<10**	0	**<10**	0	**<10**	2	**1.0**	1	0.32	3	0.69
Chromium	2,200	0	<40	0	<40	0	<40	3	3.5	2	4.5	3	5.7
Hexavalent chromium [d]	0.035	-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	0.6	0	**<50**	0	**<50**	0	**<50**	-	-	-	-	-	-
Cyanide	0.15	-	-	-	-	-	-	1	**2.2**	2	**1.4**	1	**1.4**
Lead	15	1	**63**	1	**32**	1	8	1	2.8	0	<8.7	1	9.2
Mercury	0.57	2	0.3	1	0.2	0	<0.2	2	0.14	2	0.29	1	0.13
Nickel	39	1	**140**	1	**130**	1	**80.0**	3	5.3	3	6.5	3	6.9
Selenium	10	0	<5	0	<5	0	<5	0	<2.9	0	<2.9	0	<2.9
Silver	9.4	-	-	-	-	-	-	0	<2	0	<2	0	<2
Vanadium	8.6	0	**<1000**	0	**<1000**	0	**<1000**	3	**11**	3	**10**	3	**15**
Zinc	600	-	-	-	-	-	-	3	53	2	17	2	25
Volatile Organic Compounds													
Acetone	1,400	0	<10	0	<10	0	<10	-	-	-	-	-	-
Benzene	0.45	0	<0.4	0	<0.4	0	<0.4	0	**<5**	0	**<5**	0	**<5**
2-Butanone	560	0	<50	0	<50	0	<50	0	<5	0	<5	1	2.0
Carbon disulfide	81	0	<10	0	<10	0	<10	0	<5	0	<5	0	<5
Carbon tetrachloride	0.45	0	**<0.7**	1	**3.3**	0	**<0.7**	-	-	-	-	-	-
Chlorobenzene	7.8	0	<0.4	0	<0.4	0	<0.4	0	<5	0	<5	0	<5
Chloroform	0.22	0	**<0.5**	0	**<0.5**	0	**<0.5**	1	**6.0**	0	**<5**	0	**<5**
1,2-Dibromoethane	0.0075	-	-	-	-	-	-	0	**<5**	0	**<5**	0	**<5**
1,2-Dichloroethane	0.17	0	**<0.6**	0	**<0.6**	0	**<0.6**	0	**<5**	0	**<5**	0	**<5**
1,1-Dichloroethene	28	-	-	-	-	-	-	0	<5	0	<5	0	<5
1,4-Dioxane	0.78	0	**<50**	0	**<50**	0	**<50**	0	**<500**	0	**<500**	0	**<500**
1,1-Dichloroethylene	28	0	<0.6	0	<0.6	0	<0.6	-	-	-	-	-	-
2,4-Dinitrotoluene	0.24	-	-	-	-	-	-	0	**<10**	0	**<10**	0	**<10**
Ethylbenzene	1.50	0	<0.7	0	<0.7	0	<0.7	0	**<5**	0	**<5**	0	**<5**
Ethyl Dibromide	-	0	**<1**	0	**<1**	0	**<1**	-	-	-	-	-	-
Styrene	120	0	<0.5	0	<0.5	0	<0.5	0	<5	0	<5	0	<5
Tetrachloroethene	4.1	-	-	-	-	-	-	0	**<5**	0	**<5**	0	**<5**
Toluene	110	1	5.5	1	6	0	<0.4	0	<5	0	<5	0	<5

Table 3-2
Available Characterization Data for Surface Water in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Surface Water Characterization Sample Results (1990) [b]						Phase II RFI Surface Water Sample Results (1999) [c]					
		Upstream		NPDES Outfall		Downstream		Upstream		NPDES Outfall		Downstream	
		No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result
1,1,1-Trichloroethane	800	-	-	-	-	-	-	0	<5	0	<5	0	<5
Trichloroethylene	0.28	1	**5.1**	1	**5.2**	1	**4.8**	0	**<5**	0	**<5**	1	**3.0**
1,2,4-Trimethylbenzene	1.5	-	-	-	-	-	-	0	**<5**	0	**<5**	0	**<5**
1,3,5-Trimethylbenzene	12	-	-	-	-	-	-	0	<5	0	<5	0	<5
Xylene	19	1	2	0	<0.6	1	0.6	0	<5	0	<5	0	<5
Semi-volatile Organic Compounds													
Anthracene	180	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Acenaphthene	53	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Benzenethiol	1.7	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Benzo(a)anthracene	0.034	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Benzo(b)fluoranthene	0.034	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Benzo(k)fluoranthene	0.34	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Benzo(a)pyrene	0.0034	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
bis(2-ethylhexyl)phthalate	5.6	0	<5	0	<5	0	<5	0	**<10**	0	**<10**	0	**<10**
Butylbenzylphthalate	16	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Chrysene	3.4	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Cresol-o	93	-	-	-	-	-	-	0	<10	0	<10	0	<10
Cresol-p	190	-	-	-	-	-	-	0	<10	0	<10	0	<10
Cresols	190	0	<5	0	<5	0	<5	-	-	-	-	-	-
Dibenz(a,h)anthracene	0.0034	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Dibenzofuran	0.79	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Dichlorobenzene	0.48	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
1,2-Dichlorobenzene	30	-	-	-	-	-	-	0	<10	0	<10	0	<10
1,3-Dichlorobenzene	0.48	-	-	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	0.48	-	-	-	-	-	-	0	**<10**	0	**<10**	0	**<10**
Diethylphthalate	1,500	0	<5	0	<5	0	<5	-	-	-	-	-	-
7,12-Dimethylbenz(a)anthracene	0.00010	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
2,4-Dimethylphenol	36	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Dimethylphthalate	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
2,4-Dinitrophenol	3.9	0	**<50**	0	**<50**	0	**<50**	-	-	-	-	-	-
Di-n-butylphthalate	90	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Di-n-octylphthalate	20	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Dinbz(a,h)acridine	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Fluoranthene	80	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Fluorene	29	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Indene	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-

Table 3-2
Available Characterization Data for Surface Water in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Surface Water Characterization Sample Results (1990) [b]						Phase II RFI Surface Water Sample Results (1999) [c]					
		Upstream		NPDES Outfall		Downstream		Upstream		NPDES Outfall		Downstream	
		No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result
Indeno(1,2,3-cd)pyrene	0.034	-	-	-	-	-	-	0	**<10**	0	**<10**	0	**<10**
Methyl chrysene	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
1-Methylnaphthalene	1.1	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
2-Methylnaphthalene	3.6	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Naphthalene	0.17	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Nitrobenzene	0.14	-	-	-	-	-	-	0	**<10**	0	**<10**	0	**<10**
4-Nitrophenol	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Phenanthrene	-	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Phenol	580	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Pyrene	12	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Pyridine	2.0	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Quinoline	0.024	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-

Notes:
All sample results and screening levels are presented in micrograms per liter (µg/L).

\- = not applicable; analysis not performed or screening value not available for this chemical
< = analyte not detected; value shown is the detection limit
NPDES - National Pollutant Discharge Elimination System
RFI - Resource Conservation and Recovery Act Facility Investigation
µg/L - micrograms per liter

Bolding of a chemical name indicates that the screening level was exceeded by a detected concentration or detection limit; **bolding** of a value indicates that the screening level was exceeded by that value.

[a] United States Environmental Protection Agency Tap Water Regional Screening Levels (USEPA, 2014a). Screening levels for non-carcinogenic compounds are based on a hazard quotient (HQ) of 0.1.
[b] Maximum of two surface water samples collected from the surface and mid-depth in the water column on November 9, 1989, as reported in the Surface Water and Sediment Characterization Report (Total Petroleum, Inc.) dated 9/4/1990.
[c] Average detected concentration or maximum reporting limit from three samples collected upstream, at the NPDES outfall, and downstream of the Site on October 7, October 27, and November 8th, 1999.
[d] Speciated chromium analyses were not performed on historic samples; however surface water samples collected for the Human Health Risk Assessment will be analyzed for hexavalent chromium.

Table 3-3
Available Characterization Data for On-Site Sediment
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Historic Sample Results [b]				
		Number of Samples	Number of Detects	Detection Frequency (%)	Maximum Detection Limit for Non-Detects	Maximum Detected Concentration
Metals						
Antimony	47	3	3	100	-	1.9
Arsenic	3.0	4	4	100	-	**9.1**
Barium	22,000	4	4	100	-	989
Beryllium	230	4	4	100	-	0.77
Cadmium	98	3	3	100	-	0.52
Chromium	180,000	10	10	100	-	336
Hexavalent chromium [c]	6.3	-	-	-	-	-
Cyanide	13	3	2	67	0.20	0.96
Lead	800	10	10	100	-	559
Mercury	4.0	2	2	100	-	0.33
Nickel	2,200	4	4	100	-	18
Selenium	580	2	2	100	-	9.5
Silver	580	1	0	0	0.16	-
Vanadium	580	4	4	100	-	54
Zinc	35,000	4	4	100	-	135
Volatile Organic Compounds						
Benzene	5.1	8	8	100	-	0.85
2-Butanone	19,000	2	1	50	0.0060	0.0030
Carbon disulfide	350	3	3	100	-	0.039
Chlorobenzene	130	1	0	0	0.0060	-
Chloroform	1.4	1	0	0	0.0060	-
1,2-Dichloroethane	2.0	1	0	0	0.0060	-
1,4-Dioxane	23	1	0	0	0.65	-
1,1-Dichloroethylene	100	1	0	0	0.0060	-
Ethylbenzene	25	7	3	43	0.0060	2.2
Ethyl Dibromide	9.8	1	0	0	0.0060	-
Styrene	3,500	1	0	0	0.0060	-
Tetrachloroethylene	39	1	0	0	0.0060	-
1,1,1-Trichloroethane	3,600	1	0	0	0.0060	-
Trichloroethylene	1.9	1	0	0	0.0060	-
Toluene	4,700	8	7	88	0.0060	1.5
1,2,4-Trimethylbenzene	24	3	2	67	0.0060	0.0050
Xylene	250	7	5	71	0.0060	7.3
Semi-volatile Organic Compounds						
Anthracene	23,000	10	8	80	9.9	2
Acenaphthene	4,500	1	0	0	0.44	-
Benzo(a)anthracene	2.9	4	4	100	-	1.6
Benzo(b)fluoranthene	2.9	4	4	100	-	0.88
Benzo(a)pyrene	0.29	4	4	100	-	**1.1**
bis(2-ethylhexyl)phthalate	160	2	2	100	-	2.8
Butylbenzylphthalate	1,200	1	0	0	0.44	-
Chrysene	290	10	8	80	9.9	4.5
Cresol-o	4,100	1	0	0	0.44	-
Cresol-p	8,200	1	0	0	0.44	-
Dibenz(a,h)anthracene	0.29	2	2	100	-	**1.1**
1,2-Dichlorobenzene	930	1	0	0	0.44	-
1,4-Dichlorobenzene	11	1	0	0	0.44	-
7,12-Dimethylbenz(a)anthracene	0.0085	1	0	0	0.44	-
2,4-Dimethylphenol	1,600	1	0	0	0.44	-
Di-n-butylphthalate	8,200	1	0	0	0.44	-
Di-n-octylphthalate	820	1	0	0	0.44	-
Fluoranthene	3,000	3	3	100	-	0.35
Fluorene	3,000	1	1	100	-	0.22

Table 3-3
Available Characterization Data for On-Site Sediment
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Historic Sample Results [b]				
		Number of Samples	Number of Detects	Detection Frequency (%)	Maximum Detection Limit for Non-Detects	Maximum Detected Concentration
Indeno(1,2,3-cd)pyrene	2.9	2	2	100	-	1.0
1-Methylnaphthalene	73	3	2	67	0.44	0.26
2-Methylnaphthalene	300	4	4	100	-	0.51
Naphthalene	17	8	3	38	10	12
Nitrobenzene	22	1	0	0	0.4400	-
Phenanthrene	-	10	10	100	-	25
Phenol	25,000	1	0	0	0.44	-
Pyrene	2,300	4	4	100	-	7.0
Pyridine	120	1	0	0	0.44	-

Notes:
All sample results and screening levels are presented in milligrams per kilogram (mg/kg).

% = percent
- = not applicable

Bolding of a chemical name indicates that the screening level was exceeded by a detected concentration or detection limit; **bolding** of a sample result, or reporting limit for non-detects, indicates that the screening level was exceeded by that value.

[a] United States Environmental Protection Agency Industrial Soil Regional Screening Levels (USEPA, 2014a). Screening levels for non-carcinogenic compounds are based on a hazard quotient (HQ) of 0.1.
[b] Summary statistics presented here are based on sediment sampling results from the Surface Water and Sediment Characterization Report (Total Petroleum, Inc.) dated 9/4/1990, sediment sampling results from the Phase II RFI Report (Earth Tech Inc.) dated June 2000, and one shallow soil result, from the location of SWMU 23, which was dry at the time, from the Final RFI Report (RSA) dated 8/4/1992.
[c] Speciated chromium analyses were not performed on historic samples; however sediment samples collected for the Human Health Risk Assessment will be analyzed for hexavalent chromium.

Table 3-4
Available Characterization Data for Sediment in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	1989 Sediment Characterization Sample Results [b]		
		Upstream	NPDES Outfall	Downstream
Metals				
Antimony	47	<10	<10	<10
Arsenic	3.0	<2	<2	<2
Barium	22,000	100	120	100
Cadmium	98	<2	<2	<2
Chromium	180,000	10	10	12
Hexavalent chromium [c]	6.3	-	-	-
Cobalt	35	<10	<10	<10
Lead	800	23	31	8.0
Mercury	4.0	<0.1	<0.1	<0.1
Nickel	2,200	<10	<10	0.090
Selenium	580	<1	<1	<1
Vanadium	580	<200	<200	<200
Zinc	35,000	-	-	-
Volatile Organic Compounds				
Acetone	67,000	<10	<10	<10
Benzene	5.1	<0.4	0.70	<0.4
2-Butanone	19,000	<50	<50	<50
Carbon disulfide	350	<10	<10	<10
Carbon tetrachloride	2.9	<0.7	<0.7	<0.7
Chlorobenzene	130	1.8	<0.4	<0.4
Chloroform	1.4	<0.5	<0.5	<0.5
1,2-Dichloroethane	2.0	<0.6	<0.6	<0.6
1,4-Dioxane	23	**<50**	**<50**	**<50**
1,1-Dichloroethylene	100	<0.6	<0.6	<0.6
Ethylbenzene	25	1.7	<0.7	<0.7
Ethyl Dibromide	9.8	<1	<1	<1
Styrene	3,500	<0.5	<0.5	<0.5
Toluene	4,700	<0.4	<0.4	<0.4
Trichloroethylene	1.9	<0.6	<0.6	<0.6
Xylene	250	9.9	6.2	2.4
Semi-volatile Organic Compounds				
Anthracene	23,000	<500	<500	<500
Acenaphthene	4,500	<500	<500	<500
Benzenethiol	120	**<500**	**<500**	**<500**
Benzo(a)anthracene	2.9	**<500**	**<500**	**<500**
Benzo(b)fluoranthene	2.9	**<500**	**<500**	**<500**
Benzo(k)fluoranthene	29	**<500**	**<500**	**<500**
Benzo(a)pyrene	0.29	**<500**	**<500**	**<500**
bis(2-ethylhexyl)phthalate	160	**<500**	**<500**	**<500**
Butylbenzylphthalate	1,200	<500	<500	<500
Chrysene	290	**<500**	**<500**	**<500**
Cresols	8,200	<500	<500	<500
Dibenzofuran	100	**<500**	**<500**	**<500**
Dichlorobenzene	-	<500	<500	<500
Diethylphthalate	66,000	<500	<500	<500

Table 3-4
Available Characterization Data for Sediment in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	1989 Sediment Characterization Sample Results [b]		
		Upstream	NPDES Outfall	Downstream
7,12-Dimethylbenz(a)anthracene	0.0085	**<500**	**<500**	**<500**
2,4-Dimethylphenol	1,600	<500	<500	<500
Dimethylphthalate	-	<500	<500	<500
2,4-Dinitrophenol	160	**<5000**	**<5000**	**<5000**
Di-n-butylphthalate	8,200	700	3200	900.0
Di-n-octylphthalate	820	<500	<500	<500
Dinbz(a,h)acridine	-	<500	<500	<500
Dinbz(a,h)anthracene	0.29	**<500**	**<500**	**<500**
Fluoranthene	3,000	<500	<500	<500
Fluorene	3,000	<500	<500	<500
Indene	-	<500	<500	<500
Methyl chrysene	-	<500	<500	<500
1-Methylnaphthalene	73	**<500**	**<500**	**<500**
2-Methylnaphthalene	300	**<500**	**<500**	**<500**
Naphthalene	17	**<500**	**<500**	**<500**
4-Nitrophenol	-	<500	<500	<500
Phenanthrene	-	<500	<500	<500
Phenol	25,000	<500	<500	<500
Pyrene	2,300	<500	<500	<500
Pyridine	120	**<500**	**<500**	**<500**
Quinoline	0.77	**<500**	**<500**	**<500**

Notes:
All sample results and screening levels are presented in milligrams per kilogram (mg/kg).

\- = not applicable; analysis not performed or screening value not available for this chemical
< = analyte not detected; value shown is the detection limit
NPDES - National Pollutant Discharge Elimination System

Bolding of a chemical name indicates that the screening level was exceeded by a detected concentration or detection limit; **bolding** of a result value indicates that the screening level was exceeded by that value.

[a] United States Environmental Protection Agency Industrial Soil Regional Screening Levels (USEPA, 2014a). Screening levels for non-carcinogenic compounds are based on a hazard quotient (HQ) of 0.1.

[b] Detected concentration or reporting limit from samples collected upstream, at the NPDES outfall, and downstream of the Site, as reported in the Surface Water and Sediment Characterization Report (Total Petroleum, Inc.) dated 9/4/1990.

[c] Speciated chromium analyses were not performed on historic samples; however sediment samples collected for the Human Health Risk Assessment will be analyzed for hexavalent chromium.

Table 4-1
Modeling Assumptions to be Used in the Human Health Risk Assessment for Surface Water and Sediment
MRP Properties Company, LLC - Arkansas City, Kansas

Exposure Parameter	Units	Current / Future Commercial or Industrial Worker	Future Utility or Construction Workers	Off-Site Recreational User: Adolecsent	Off-Site Recreational User: Adult
General					
BW = body weight	kg	80 [a]	80 [a]	56.8 [b]	80 [a]
SA = surface area	cm^2	3,470 [a]	3,470 [a]	4,113 [c]	5,715 [c]
ATc = averaging time for carcinogens	days	25,550 [a]	25,550 [a]	25,550 [a]	25,550 [a]
ATn = averaging time for non-carcinogens	days	9,125 [a]	365 [d]	1,825 [e]	9,125 [e]
ED = exposure duration	years	25 [a]	1 [d]	5 [e]	25 [e]
Exposure Modeling Parameters for Dry Ponds					
IR_S = dry sediment ingestion rate	mg / day	100 [a]	330 [f]	-	
AF = soil-to-dermal adherence factor	mg / cm^2	0.12 [a]	0.3 [f]	-	
ABS = absorption fraction through skin for chemicals in sediment	unitless	CS	CS	-	
ET = exposure time for inhalation	hours / 24 hr day	8 / 24 [g]	8 / 24 [g]	-	
VF = volatilization factor for constituents from sediment	m^3 / kg	CS	CS	-	
PEF = particulate emission factor	m^3 / kg	SS [h]	SS [h]	-	
EF = exposure frequency	days / year	26 [g]	50 [d]	-	
Exposure Modeling Parameters for Wet Ponds					
IR_S = sediment ingestion rate	mg / day	100 [a]	330 [a]	-	
IR_W = water ingestion rate	mL / hour	10.6 [i]	21 [j]	-	
DA = absorbed dose per dermal contact	mg / cm^2-event	CS	CS	-	
VF = volatilization factor for constituents from water	m^3 / kg	CS	CS	-	
ET = exposure time for inhalation and dermal cotnact	hours / 24 hr day	8 / 24 [g]	8 / 24 [g]	-	
EF = exposure frequency	days / year	8 [g]	50 [d]	-	
Exposure Modeling Parameters for the Walnut River					
IR_S = sediment ingestion rate	mg / day	-	-	200 [a]	100 [a]
IR_W = water ingestion rate	mL / hour	-	-	49 [i]	21 [i]
DA = absorbed dose per dermal contact	mg / cm^2-event	-	-	CS	CS
VF = volatilization factor for constituents from water	m^3 / kg	-	-	CS	CS
ET = exposure time for dermal contact	hours / 24 hr day	-	-	0.75 / 24 [e]	0.75 / 24 [e]
EF = exposure frequency	days / year	-	-	52 [e]	52 [e]
Fish Ingestion Rate	mg / day	-	-	0.054 [a]	0.054 [a]

Notes

cm^2 - square centimeters
CS - chemical-specific
kg - kilogram
m^3/kg - cubic meters per kilogram
mg/cm^2 - milligrams per square centimeter
mg/day - milligrams per day
mL/hour - milliliters per hour
NA - not applicable
SS - site-specific
USEPA - U.S. Environmental Protection Agency

[a] USEPA (2014b) Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.a-120. February. Exposure parameters for the commercial or industrial receptor are equal to the outdoor industrial

[b] Adolescent (11 to 16 years of age) body weight from Table 8-1 of the USEPA's Exposure Factors Handbook (USEPA, 2011).

[c] Skin surface area for a recreational user fishing and wading in the Walnut River is equal to the sum of the hands and feet surface area, half of the arm and a quarter of the leg surface area in Table 7-2 of the USEPA's Exposure Factors Handbook (USEPA, 2011). Surface area for an 11 to 16 year old adolescent is for males and females combined; the surface area for an adult is for a male, as this will be protective of a female recreator.

Table 4-1
Modeling Assumptions to be Used in the
Human Health Risk Assessment for Surface Water and Sediment
MRP Properties Company, LLC - Arkansas City, Kansas

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[d] A construction or utility worker is assumed to be on Site 50 days over the course of one year. Although work would likely take place during the summer months, it is conservatively assumed that this work takes place either entirely during the period when the pond is dry, or when the pond has water in it. The risk results from each scenario will be presented in the risk assessment report.

[e] A recreational user is assumed to use the Walnut River for fishing for eight hours per day, one day per weekend during the spring, summer, and fall, for 5 years as an adolescent and 25 years as an adult. The exposure time for dermal contact with surface water during activities such as wading and hand washing is assumed to be 45 minutes out of the 8 hour day.

[f] USEPA (2002) Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-25. December. Exposure parameters for the commercial or industrial receptor are equal to the outdoor industrial worker.

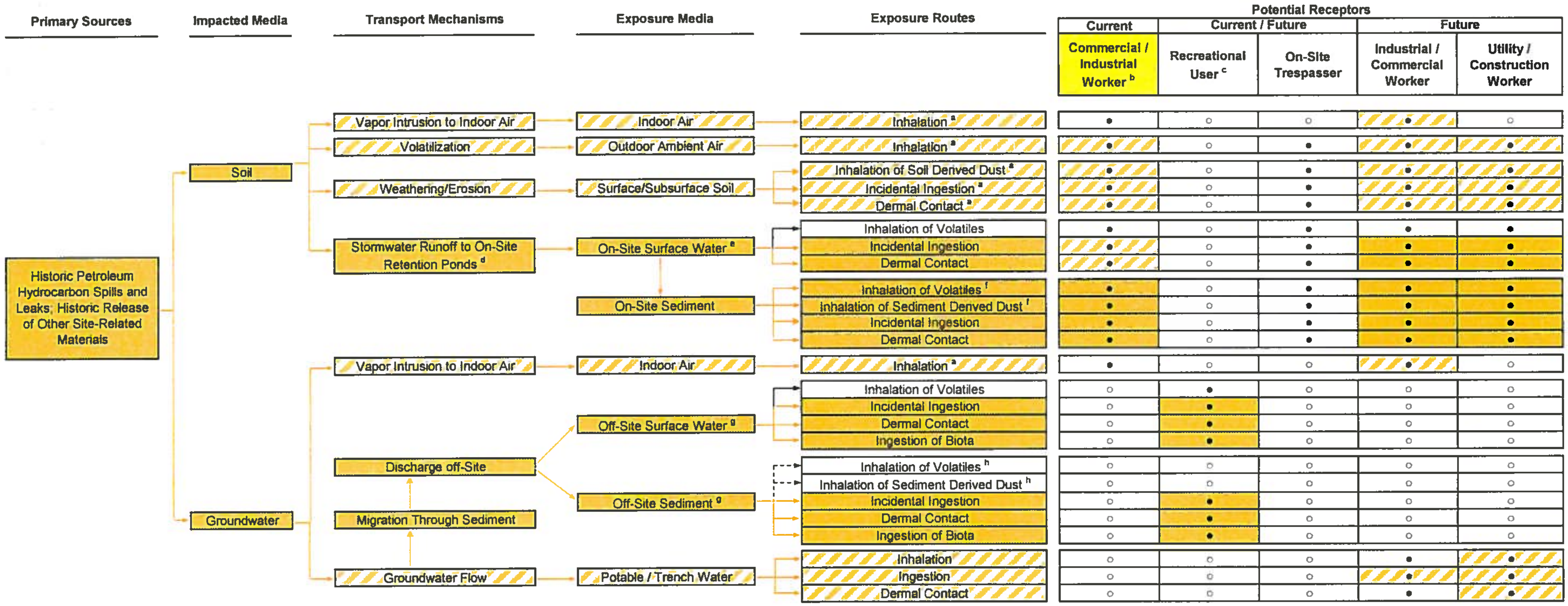
[g] A worker at an industrial or commercial facility is expected to spend a day mowing or otherwise maintaining the area around the ponds once a week during April through September (i.e., 26 weeks per year). It is further assumed that the ponds will have no water in them during this period, such that the outdoor worker is exposed to dry pond sediment only. Although it is unlikely that the ponds would recieve significant enough rain during late spring or early fall, it is possible that an outdoor worker would be exposed to wet pond sediment and surface water for 8 weeks per year. A construction or utility worker working on in the pond is expected to be exposed to media for a 8 hour work day.

[h] Pond-specific particulate emission factors will be calculated according to the site area for each pond according to modeling parameters and methods in Appendix D of USEPA (2002) for a future commercial / industrial worker, and methods and modeling parameters in Appendix E for a future construction / utility worker.

[i] Ingestion rate for a future outdoor worker is equal to the upper confidence limit on the mean incidental water ingestion rate for walking in water from Table 3-93 of the Exposure Factor Handbook (USEPA, 2011). As described in EPA Comments on the draft Human Health Risk Assessment for Surface Water and Sediment Work Plan dated September 3, 2014, the incidential ingestion rate for wading is equal to the mean value from Table 3-5 of USEPA (2011).

[j] Default incidential ingestion rate for construction workers recommended by Region 7 EPA in the September 3, 2014 Comments on the Human Health Risk Assessment for Surface Water and Sediment Work Plan.

Figure 4-1
Human Health Conceptual Site Model for Surface Water and Sediment
MRP Properties Company, LLC - Arkansas City, Kansas



Notes:

Complete Exposure Pathway
Potentially Complete but Insignificant Pathway
Incomplete Pathway

Complete Exposure Pathway - Evaluated in the Soil and Groundwater HHRA for the Site (refer also to the Conceptual Site Model in the Soil and Groundwater HHRA for complete soil and groundwater pathways)
Complete Exposure Pathway
Potentially Complete but Insignificant Pathway
Incomplete Exposure Pathway

[a] Complete exposure pathways for soil are evaluated in the Human Health Risk Assessment for Soil and Groundwater (MWH, 2014).
[b] Current industrial receptors at the Site include workers at the asphalt terminal and maintenance workers at the facility. Although complete exposure pathways between these receptors and Site media exist, these pathways are expected to be insignificant compared with exposures associated with future receptors, and therefore will not be quantitatively evaluated.
[c] Recreational users include adolescents and adults who use the Walnut River for fishing; this pathway includes wading exposures.
[d] Per discussion between MWH and KDHE on May 7, 2014, exposure associated with surface water in the active treatment ponds operating under a NDPES permit will not be evaluated at this time.
[e] Exposure to surface water in storm water in evaporation ponds and the stormwater pond is limited due to the infrequent occurrence of standing water.
[f] Inhalation of volatiles and sediment derived particulates is a complete exposure pathway during the dry season when the stormwater ponds are dry.
[g] The potential migration of contaminants from groundwater to surface water and sediment is currently incomplete because contaminated water is captured and treated prior to discharge to the Walnut River under a NPDES permit. However, the migration of contaminants in on-Site groundwater to surface water and sediment within the Walnut River may have occurred prior to installation and start-up the groundwater extraction and treatment system.

MWH

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AWMD/WRAP-KNRP

July 14, 2014

Chief of the Hazardous Waste Permits Section
Kansas Department of Health and Environment
Bureau of Waste Management
ATTN: Mostafa Kamal, P.E., CHMM
1000 SW Jackson, Suite 320
Topeka, Kansas 66612-1366

U.S. Environmental Protection Agency, Region 7
Air and Waste Management Division
RCRA Corrective Action & Permits Branch
ATTN: Brad Roberts, P.G.
11201 Renner Boulevard
Lenexa, Kansas 66219

Re: Human Health Risk Assessment Work Plan for Surface Water and Sediment
MRP Properties Company, LLC – Arkansas City, Kansas
Facility ID: KSD 087418695
VIA FEDERAL EXPRESS TRK#'s 7706 4126 5851 / 7706 4124 7874

Dear Mr. Kamal and Mr. Roberts:

MWH Americas, Inc. (MWH) is submitting the attached Human Health Risk Assessment Work Plan for Surface Water and Sediment (Work Plan) on behalf of MRP Properties Company, LLC. (MRP).

Two copies of the Work Plan are enclosed for the USEPA and one copy is enclosed for the KDHE. Additionally, Two CDs containing the HHRA in Adobe PDF format is enclosed for the USEPA and one CD is enclosed for the KDHE.

If you have any questions or comments, please contact Brenda Epperson, MRP at 210/345-4619 or Jay Mednick at 303/291-2262.

Sincerely,
MWH Americas, Inc.

Joseph F. Med

Joseph (Jay) F. Mednick P.G.
Principal Hydrogeologist

Enclosures

Cc: Kent Biggerstaff – MRP Properties Company, LLC (w/encl)
Brenda Epperson – MRP Properties Company, LLC (w/encl)
Mark Vishnefske – Kansas Department of Health and Environment
Bruce Narloch, PhD. – MWH Americas, Inc. (w/encl)

Human Health Risk Assessment Work Plan for Surface Water and Sediment

Former Total Petroleum Refinery
Arkansas City, Kansas

PREPARED FOR:

MRP Properties Company, LLC.
1400 South M Street
Arkansas City, Kansas 67005

PREPARED BY:

MWH

BELLEVUE, WASHINGTON

AND

DENVER, COLORADO

DATE:

JULY 18, 2014
REVISED SEPTEMBER 30, 2014

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^oF	degrees Fahrenheit
$\mu g/m^3$	micrograms per cubic meter
ABS_{GI}	oral absorption efficiency
AMSL	above mean sea level
AST	aboveground storage tank
bgs	below ground surface
CA	Canadian Fine Silty Loam
CDL	Construction Debris Landfill
CMS	Corrective Measures Study
cm^2	square centimeters
COPC	constituent of potential concern
CSF	cancer slope factor
CSM	conceptual site model
DA	Dale Silt Loam
EPC	exposure point concentration
EUs	Exposure Units
FCC	fluid catalytic cracker
ft	feet
FTF	former Tank Farm
EUSSI	Exposure Unit Supplemental Soil Investigation
HEAST	Health Effects Assessment Summary Tables
HFA	hydrofluoric acid
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
ILCR	incremental lifetime cancer risk
IUR	inhalation unit risk
IRIS	Integrated Risk Information System
JSA	Junk Storage Area
kg	kilograms
kg/mg	kilograms per milligram
KDHE	Kansas Department of Health & Environment
LG	Lincoln-Tivoli Complex
LTU	Land Treatment Unit
LUCs	land use controls
m^3/kg	cubic meters per kilogram
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/cm^2-day	milligrams per square centimeters per day
mg/m^3	milligrams per cubic meter
$mg/\mu g$	milligrams per microgram
MRP	MRP Properties Company, LLC
MDL	method detection limit
MRL	method reporting limit

MWH	MWH Americas, Inc.
NPDES	National Pollutant Discharge Elimination System
PA	Process Area
PAH	polycyclic aromatic hydrocarbon
PID	photoionization detector
PPRTV	Provisional Peer Reviewed Toxicity Values
RAGS	Risk Assessment Guidance for Superfund
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RfC	reference concentration
RfD	reference dose
RFI	RCRA Facility Investigation
RSL	Regional Screening Level
SLERA	Screening Level Ecological Risk Assessment
SSB	Supplemental Soil Borings
SSI	Supplemental Soil Investigation
SVOC	semivolatile organic compound
SWMU	solid waste management unit
UCL	upper confidence limit
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
VD	Verdigris Silt Loam
VISL	Vapor Intrusion Screening Level
VOC	volatile organic compound
VSI	visual site inspection
Work Plan	HHRA Work Plan

1.0 INTRODUCTION

This human health risk assessment (HHRA) work plan for surface water and sediment was prepared by MWH Americas, Inc. (MWH) on behalf of MRP Properties Company, LLC (MRP) for the former Total Petroleum Refinery in Arkansas City, Kansas (the Site). In support of Resource Conservation and Recovery Act (RCRA) Corrective Measures Study (CMS) activities for the Site, MRP submitted a draft Human Health Risk Assessment (HHRA) Work Plan on January 25, 2013, and a Data Gap Investigation (DGI) Work Plan on February 11, 2013, to the Kansas Department of Health & Environment (KDHE) and the U.S. Environmental Protection Agency Region 7 (USEPA). The KDHE and USEPA provided written comments, dated July 19, 2013. Among other comments, the agencies requested that MRP conduct a baseline HHRA for surface water and sediment, and an ecological risk assessment (ERA) for soil, surface water, and sediment. This Work Plan outlines the methods and assumptions to be used in the preparation of a baseline HHRA for surface water and sediment at the Site. Methods and assumptions to be used in an ERA for soil, surface water, and sediment will be presented in a separate work plan.

1.1 BACKGROUND

1.1.1 Site Location and History

MRP is the current owner of the Site, which is located at 1400 South M Street in Arkansas City, Cowley County, Kansas. The Site occupies approximately 267 acres located within parts of Section 31 and 32 of Township 34 South and Range 4 East; and Section 5 of Township 35 South and Range 4 East, near the confluence of the Walnut River and the Arkansas River. The eastern boundary of the Site is approximately ½ mile upstream of the confluence of the two rivers, as shown on Figure 1-1. A U.S. Army Corps of Engineers (USACE) levee system along the Arkansas and Walnut rivers protects Arkansas City and the Site from floods.

The former Total Petroleum Inc. (Total) refinery was constructed in the 1920s, and operational until 1996; the Site is currently regulated under a RCRA post closure care permit with KDHE as the lead agency. A RCRA Facility Investigation (RFI) Report (completed August, 1992), a Phase II RFI Report (completed June, 2000), and USEPA's Environmental Indicator (EI) process determined Groundwater Migration and Current Human Exposures were under control (USEPA, 2000a, 2000b). A Corrective Measures Study (CMS) work plan (completed February, 2002), and a corrective action objectives document (completed May, 2005) have been approved by the USEPA (May, 2005). In addition, an EUSSI Report was prepared for a portion of the Site and submitted to the agencies in April 2011. In a May 24, 2012 letter from KDHE, the agencies noted that the EUSSI Report was intended to be used for risk screening and not as a baseline risk assessment. As such, no further changes to the EUSSI were necessary; however, the agencies requested that MRP consider comments on the EUSSI when developing baseline risk assessment methods.

Since initial operation in the 1920s, the Site has had several different owners. The Site was purchased by Total in April 1978 and this entity was the last owner to operate the former refinery. Refining operations (alkylation, crude, hydrocracker, reformer, etc.) at the facility were discontinued September 1996. The process units in the main process area and a majority of the tanks associated with the refinery were demolished by 2003. Figure 1-2 contains a plan delineating major areas at the Site. Current Site use consists of a terminal operation where asphalt is transported by truck to the terminal, stored, and then transported by truck to customers. The terminal does not process, mix, or blend asphalt at the Site.

As a result of this long history of refining activity, petroleum is present in the subsurface at the Site. Hydrocarbon recovery from both the saturated and unsaturated zone has been ongoing since the early 1940s. A formal groundwater restoration program (hydrocarbon recovery) was initiated in 1982.

1.1.2 Surface Water Features

On-Site surface water exists in two primary impoundment types: active treatment ponds that comprise the final stages of the groundwater treatment system, and seasonally wet stormwater detention basins. These impoundments are described in greater detail in Section 2.1.2; however, human health exposures associated with active water treatment ponds will not be quantitatively evaluated at this time.

Off-Site surface water exists primarily in the Arkansas and Walnut Rivers; the relationship between these rivers and the Site, including potential sources of contamination, is described in Section 2.1.2.

1.1.3 Previous RCRA Investigations

A sediment and surface water characterization was conducted in 1989 and 1990 followed by a soil and groundwater investigation in 1990 culminating in the Final RFI Report (RSA, 1992). These investigations addressed soil, groundwater, surface water, and sediment at the Site. Additional delineation was conducted as part of a Phase II RFI investigation in 1999. The results of soil and groundwater investigations for the Site are described in the HHRA Work Plan for Soil and Groundwater (MWH, 2014); surface water and sediment investigation results are summarized in Section 3 of this Work Plan.

1.1.4 Future Site Use and Risk Assessment Framework

The Site is currently zoned industrial, and the most likely scenario for future land use at the Site is redevelopment as commercial or industrial properties. Under this future land use, it is likely that the current stormwater retention ponds will remain in use. In the event that land use for these ponds changes, the basins will likely be backfilled, eliminating exposure for future receptors.

Use of the active treatment system ponds will most likely continue unchanged until the groundwater protection standards (GWPS) are achieved at the downgradient boundary of the Site, and therefore MRP is not seeking to close units associated with the treatment system at this time. Per discussion with KDHE, evaluation of potential human health risk associated with exposure to surface water and sediment at the active treatment system ponds will be performed upon closure of the units (i.e., SWMUs 3, 4, 5, 6, 7, and 8) associated with this system.

1.2 PURPOSE AND SCOPE

The purpose of this Work Plan is to describe the methods and assumptions that will be used during the preparation of a baseline HHRA for surface water and sediment for the Site, including an evaluation of existing data and additional data requirements. Human health cancer risk and noncancer hazard estimates associated with impacted surface water and sediment will be calculated following additional Site characterization to address data gaps for these media.

1.3 ORGANIZATION

This Work Plan consists of five sections, as described below.

- **Section 1.0 – Introduction:** Summarizes the Site background and presents the purpose and scope and organization of this Work Plan.
- **Section 2.0 – Project Setting:** Presents detailed descriptions and operational histories for the Site, and summarizes the environmental setting.
- **Section 3.0 – Data Summary and Evaluation:** Presents existing Site characterization data, and describes the data usability requirements for environmental data that will be used in the HHRA for surface water and sediment.
- **Section 4.0 – Human Health Risk Assessment Approach:** Describes the methods and assumptions to be used in the preparation of a baseline HHRA for surface water and sediment at the Site.
- **Section 5.0 – References:** Lists the references cited in this Work Plan

2.0 PROJECT SETTING

A general description of the Site setting is presented in this section.

2.1 FACILITY DESCRIPTION

The Site is located southeast of the incorporated limits of Arkansas City in southwestern Cowley County, Kansas. It occupies approximately 267 acres northwest of the confluence of the Walnut and Arkansas Rivers. Petroleum refining facilities occupied the former Process Area (PA) in the northern portion of the Site, while the former Tank Farm, Construction Debris Landfill (CDL), Land Treatment Unit (LTU), former Junk Storage Area (JSA), and waste water treatment system occupied the southern portion of the Site. Refining facilities and infrastructure have been removed; however, former surface water impoundments remain in use for stormwater detention and as the final stages of the groundwater treatment system.

2.1.1 Site Operations

The former refinery, which was operational from the 1920s until September 1996, produced unleaded gasoline, liquefied petroleum gas (LPG), propylene, fuel oils, jet fuels, and asphalt at a nominal operating capacity of 60,000 barrels per day. The refinery received approximately 85% of its crude oil supply by pipeline and transported approximately 85% of its refined products by pipeline. The remaining product was transported by truck. The integrated refining processes included two crude fractionation units, a hydrofluoric acid (HFA) alkylation unit, two catalytic reformers, gas plant, hydrocracker, propylene splitter, sulfur recovery plant and other supporting facilities.

As a result of the long history of refining activity, petroleum is present in the subsurface in portions of the Site. Hydrocarbon recovery from both the saturated and unsaturated zone has been ongoing at the Facility since the early 1940s. In 1982, Total initiated a formal groundwater restoration program (hydrocarbon recovery) within the main part of the Site. The hydrocarbon recovery program has resulted in the installation of more than 100 groundwater monitoring wells and numerous product recovery wells throughout the Site. Most of the monitoring wells were installed for the purpose of delineating the areal extent and thickness of hydrocarbon in the groundwater beneath the Site. The current groundwater containment system operates as a corrective action requirement of the facility's Hazardous Waste Management Permit and an interim measures hydrocarbon recovery system within the Site to recover free phase hydrocarbon product. Solid waste management units (SWMUs) 4, 5, 6, 7, and 8, also known as Oxidation Ponds 1A, 1B, 2, 3, and 4, respectively, comprise the final legs of this groundwater treatment system.

Decommissioning has eliminated most of the structures at the Site including buildings, refinery process units, the tank farm, and underground piping to six feet below ground surface. Currently, a portion of the Site is used as an asphalt distribution terminal. The asphalt is received from off-Site sources via truck and then transported off-Site to customers via truck. Asphalt is not processed, blended, or mixed at the Site. Storm water runoff from the asphalt process area is captured in the lift station and sent to the North Bioreactor treatment tank (R-7101) before release to the oxidation ponds. Storm water runoff from non-process areas at the north side of the site are captured in the storm water pond (SWMU 23) and then pumped to the backup (south) bioreactor tank (R-7102) and the oxidation ponds. All stormwater is managed in the oxidation pond system before discharge to the Walnut River under the facility's National Pollution Discharge Elimination System (NPDES) permit.

2.1.2 Surface Water Features

As mentioned in Section 1.1.2, on-Site surface water exists in two primary impoundment types: active treatment ponds that comprise the final stages of the groundwater treatment system, and seasonally wet stormwater retention basins. These impoundments are described below and shown on Figure 2-1, however, as described in Section 1.1.4, based on a discussion between representatives of MWH and KDHE on May 7, 2014, potential human health risks associated with exposure to ponds in the active treatment system will not be quantified in the HHRA for surface water and sediment.

2.1.2.1 Groundwater Treatment System Ponds

In the final stages of the treatment system, groundwater flows from the bioreactor tank to Oxidation Pond No. 1A (SWMU 4), Oxidation Pond No. 1B (SWMU 5), Oxidation Pond 2 (SWMU 6), Oxidation Pond No. 3 (SWMU 7), and finally to Oxidation Pond 4 (SWMU 8) for additional biodegradation of organic compounds before discharge through a NPDES outfall to the Walnut River.

2.1.2.2 SWMUs 9, 10, 11, (Evaporation Ponds 1, 2, and 3) and SWMU 23 (Stormwater Pond)

Evaporation Ponds No. 1 through No. 3 (SWMU 9, 10, and 11) were constructed from native soil around 1956 to manage stormwater from non-process areas, and are still in use. Water in this system flows from the 375,000 gallon capacity Evaporation Pond No. 1 to the 500,000 gallon capacity Evaporation Pond No. 2 and finally to the 500,000 gallon capacity Evaporation Pond No. 3. The stormwater ponds are six to seven feet deep, and 7,000 to 10,000 square feet in surface area.

During the history of the refinery, water in Evaporation Pond No. 1 sometimes contained a sheen, and during the visual site inspection (VSI) staining was observed along the embankment (A.T. Kearney, Inc. and Harding Lawson Associates, 1987). Also during the VSI, a scum layer was observed on the water surface in Evaporation Pond No. 2, and light staining was observed on the dikes around Evaporation Pond No. 3 (A.T. Kearney, Inc. and Harding Lawson Associates, 1987).

The No. 1 Oil Trap (SWMU 23) was used to manage oily waste water beginning in the 1930s, and later to contain spills and stormwater. There is no documentation of how water and sludge were managed during this use. The No. 1 Oil Trap was removed from service in December 1986. A stormwater pond now occupies the location of the previous No. 1 Oil Trap.

Stormwater detention ponds contain little to no water during most of the year (personal communication, July 10, 2014)

2.1.2.3 Closed Surface Impoundments

The No. 1 and No. 2 closed surface impoundments (SWMUs 1 and 2) and the No. 3A aerated lagoon (part of SWMU 3) are RCRA-regulated units. These units are currently in RCRA post closure care and do not require further risk assessment.

2.1.2.4 Walnut River Surface Water

Off-Site surface water includes the Walnut and Arkansas Rivers. All stormwater runoff is contained on-Site and only discharged according to NPDES permit requirements, however, off-Site surface water and sediment may have become contaminated at historic hydrocarbon seep areas. The Arkansas River is upgradient of the Site, and is therefore not likely to have been impacted. Seeps to the Walnut River have been observed north of the Site, and near the NPDES outfall, as shown in Figure 2-2. The historic seeps were reported as a sheen on the river, and were addressed by physical barriers to prevent further off-Site migration. Currently, groundwater flow to the Walnut River is limited by the groundwater capture and treatment system; extracted and treated groundwater is discharged to the Walnut River at the NPDES permitted outfall.

NDPES discharge monitoring data indicate no impacts to the Walnut River. Exposures to sediment impacted by historic discharges is incomplete due to levee realignment work performed between 2002 and 2005 which included expanding the footprint and raising the Walnut River levee adjacent to the Site, and shifting the Walnut River away from the Site to the north and east (Figure 2-2) into formerly dry land that was excavated. The exposure pathway to current and future receptors to any historic contamination is not complete. However, sampling in the Walnut River will be conducted as described in Section 3.2 to document current conditions and determine if further evaluation is warranted.

2.2 ENVIRONMENTAL SETTING

The majority of the land surrounding the Facility is cultivated for wheat and sorghum production. A large flour mill borders the Site to the north, the area to the northwest is residential, a recreational area and the Arkansas City sewage treatment plant lie directly west of the Site, and the Kaw Wildlife Area is located to the south and southeast. The direction of groundwater flow at the Site is to the northeast. Several active oil production wells are located in the vicinity. Currently, minimal industrial activity associated with the small asphalt terminal occurs at the Site. Future land use at the Site is expected to remain industrial or commercial. The Site currently contains no significant habitat for wildlife, and enhancement for wildlife use is not planned.

2.2.1 Site and Vicinity Land Use

The Site is currently zoned industrial, and land use at the Site is expected to remain industrial. Land directly to the west is zoned single family residential. The area to the southwest is zoned heavy industrial and is the location of the Arkansas City sewage treatment plant. Land use to the north is limited industrial, including a large flour mill on the northern border. A gravel mining operation is present in industrial land to the south, and the Kaw wildlife management area is located adjacent to the site to the south and southeast. The nearest residential property east of the Site is over a quarter of a mile away across the Walnut River.

The regional and local setting of the facility is summarized in the following sections. Regional hydrogeology was investigated as part of the RFI and submitted with the August 4, 1992 Final RFI Report (RSA, 1992).

2.2.2 Geology and Soils

The Site has very little topographic relief and gently slopes towards the northeast. Facility elevations range from approximately 1,078 feet above mean sea level (AMSL), near the southern boundary of the facility, to 1,045 feet AMSL, at the east side of the facility.

The Site is located southeast of Arkansas City in Cowley County, in south central Kansas. Structurally, this area is east of the Nemaha Ridge, and west of the Dexter Anticline. Locally, the facility is located at the confluence of the Arkansas and Walnut Rivers. The region is underlain by Permian-age rocks that dip toward the west (Bayne, 1962). Quaternary alluvium overlies these Permian deposits and is found along major rivers and streams.

The areas along both the Arkansas and Walnut Rivers, including the Site, are underlain by unconsolidated Quaternary-age alluvial deposits. These deposits consist of clay, silt, sand, chert, and limestone gravel (RSA, 1992). The thickness of alluvial deposits in the region is typically less than 25 feet, although recent alluvial deposits along the Arkansas River can be as much as 50 feet in thickness.

The alluvial deposits are underlain by the bedrock of the Permian-age Chase Group which is comprised of interbedded limestone, chert, and shale. The Chase Group has a total thickness of about 350 feet; about half of which is limestone and the other half shale (Bayne, 1962). Bedrock dips to the west, with younger Permian rocks of the Sumner Group regionally overlying the Chase Group. The Chase Group overlies older Permian rocks of the Council Grove and Admire Groups. Progressively older lithologies are exposed at the surface east of the Site.

There are three prominent structures in Cowley County, the Dexter Anticline, the Winfield Anticline, and the Nemaha Anticline. The Dexter Anticline is located in the eastern part of the county and trends northeast-southwest. The east flank has a dip of over 200 feet per mile, while the west flank has a dip of about 100 feet per mile. The Winfield Anticline, which trends northeast-southwest in the central part of the county has a dip less than the Dexter Anticline but can be observed in surface features. The Nehema Anticline extends from central Oklahoma to northeast Kansas, and crosses the northwestern corner of the County. None of these structural features significantly affects the geology at the Site.

According to the United States Department of Agriculture (USDA) Soil Survey of Cowley County (1980), there are four soil types found at the facility; the Canadian Fine Silty Loam (CA), the Dale Silt Loam (DA), the Lincoln-Tivoli Complex (LG) and the Verdigris Silt Loam (VD).

The Canadian series (CA) soil is generally deep, well drained, with moderately rapid permeability. This soil type ranges in depth up to about 60 inches and is formed in loamy and sandy alluvium. Slopes of this soil type range from 0 to 1 percent. Canadian series soil is generally located in the southern portion of the Site.

The Dale series (DA) soil type is generally deep, well drained and moderately permeable. Soil depths extend to about 60 inches, and are formed in loamy alluvium. This soil type has slopes of about 0 to 1 percent and trend in an east-west direction in the central portion of the facility.

The Lincoln-Tivoli Complex (LG) soil type tends to be a deep soil that is excessively drained with rapid permeability. The depth of this soil type occurs within the upper 60 inches. This soil type is found on floodplain or terrace deposits. Slopes of this soil type range from 0 to 15 percent and are found along the Arkansas and Walnut Rivers at the northeastern and southern boundaries of the facility.

The Verdigris Series (VD) soil type is deep and moderately well drained and has moderate permeability. Soil depths extend to about 60 inches and form in silty alluvium. Slopes of this soil type are about 0 to 2 percent and are found on low terraces and floodplains. The Verdigris soil type is located on the northern side of the facility.

2.2.3 Hydrogeology

Groundwater occurs in alluvial and bedrock aquifers in the vicinity of the Site. The alluvial deposits along the Arkansas River Valley provide large quantities of water (500 to 1,000 gallons per minute) which ranges in quality from good to poor. Locally, groundwater from bedrock aquifers can yield large to small quantities of water that ranges from good to poor quality. Chloride concentrations in water wells completed in alluvial sediments at the Site vicinity range from approximately 16 ppm to 650 ppm (Bayne, 1962). Depth to groundwater is impacted by recovery wells, which run 24 hours per day, 7 days per week. The shallowest depth to groundwater recorded at the Site between 1999 and 2013 ranges from less than 10 to more than 20 feet below ground surface (bgs) (Figure 2-1).

Recharge of alluvial aquifers in the region is due mainly to infiltration of precipitation. On an intermittent basis, the Arkansas and Walnut Rivers contribute to alluvial aquifer recharge (Bayne, 1962). During flood conditions, when river water elevations are above the level of the groundwater in the aquifer, movement is in the direction of the aquifer (away from the stream) and aquifer recharge occurs. Regionally, discharge of groundwater usually occurs by flow to streams and rivers, and by evapotranspiration, pumping, and leakage into hydraulically connected aquifers.

2.2.4 Regional Surface Water

The Site is located between the Arkansas and Walnut Rivers upstream of the confluence of the two rivers. The Arkansas River flows southeasterly through Arkansas City then meanders to the northeast where it merges with the south-southeast flowing Walnut River. The two rivers are principal waterways in Cowley County.

Portions of the Site are located within the 100-year flood plain of the Walnut River and the Arkansas River. The maximum peak flow recorded on the Arkansas River is 103,000 cubic feet per second (cfs) on June 10, 1923 and on the Walnut River, the maximum peak flow recorded is 105,000 cfs on April 23, 1944. The maximum peak flow periods of record for the Arkansas and Walnut Rivers are 1903-2013 and 1898-2013, respectively.

Mean daily flows from the Arkansas City gauging station on the Arkansas River and the Walnut River for 1960 through 2010 were obtained from the USGS. For the Arkansas River at Arkansas City (USGS Station 07146500) the mean of the annual maximum mean daily flow was 29,161 cfs. The month when the annual maximum occurred was highly variable from year to year, generally occurring from March through June, or from September through November. The mean of the annual minimum mean daily flow at this station and for this period was 317 cfs. The month when the annual minimum occurred was generally either January or from August through October.

For the Walnut River at Winfield (USGS Station 07147800) the mean of the annual maximum mean daily flow for this period was 24,088 cfs. The month when the annual maximum occurred was again highly variable but most often from April through June, or in November. The mean of the annual minimum mean daily flow for the Walnut River at Winfield for this period was 56 cfs. The month when the annual minimum occurred was most often August, September, or October.

2.2.5 Climate

According to U.S. Army Corps of Engineers (USACE), December 1984, the climate of Cowley County, Kansas is normal for middle latitude, interior continental areas. It is characterized by large variations in annual and daily temperatures, long, hot summers and cold, short winters. The average daily temperature in the winter is 36.6°F. The recorded high and low temperatures for Cowley County are 118°F on August 12, 1936 and -27°F on February 13, 1905, respectively.

Long-term precipitation data are currently available for the 1971-2000 30-year climate normals period. Precipitation in Cowley County is highest during the spring and summer (April-September). Seventy-two percent of the average annual precipitation of 36.7 inches occurs during late evening or nighttime thunderstorms. Ten to eleven inches of the annual precipitation occurs as snowfall.

Occasionally, tornadoes and severe thunderstorms occur within Cowley County. Storms are usually localized in extent and are of short duration. Crop damage by hail is not as extensive in Cowley County as in areas further west.

The closest location recording data on wind speed and direction is Wichita, Kansas. The wind rose (MWH, 2011) for Wichita, Kansas (2000-2009) indicates that the prevailing wind is from the south at an annual mean speed of 13 mph. The secondary prevailing wind direction is from the north.

The average evaporation from March to November for the closest station (Elk City Lake Station, located approximately 55 miles east-northeast of the facility) was 51 inches per year, based on data from 1960 to 1992 (available period of record). No evaporation data is recorded for Arkansas City, Kansas.

3.0 DATA SUMMARY AND EVALUATION

A summary of the available surface water and sediment characterization data for the Site is presented in Section 3.1, and recommendations for additional data collection are presented in Section 3.2.

3.1 DATA SUMMARY

The 1990 RFI was conducted to address potential contamination in soil, groundwater, surface water, and sediment at the Site (RSA, 1992). Additional delineation was conducted during the Phase II RFI in 1999 (Earth Tech, 2000). Soil and groundwater data are described in the HHRA Work Plan for those media (MWH, 2014); surface water and sediment data are described in the following sections.

3.1.1 Surface Water

Surface water data collected during the 1990 RFI include one sample each from SWMUs 9 and 11, and river locations upstream of the Site, near the NPDES outfall, and at the downstream corner of the Site (Figure 2-2). Samples from the Evaporation Ponds in 1990 were submitted for a limited analysis suite; detected chemicals include ethylbenzene, toluene, and xylenes in Evaporation Pond No. 1 and chromium and lead in Evaporation Pond No. 3 (Table 3-1). Compounds detected in samples collected from the Walnut River in 1990 at upstream, outfall, and downstream locations include several metals and volatile organic compounds (VOCs), including BTEX (Table 3-2).

Surface water sampling during the Phase II RFI was limited to off-Site samples collected from the Walnut River upstream of the Site (SW-1), at the NPDES outfall (SW-2), and downstream (SW-3) at the eastern corner of the CDL (Figure 2-2). Metals and cyanide were detected in samples from upstream of the Site, at the outfall, and at the downstream corner of the Site. One VOC, chloroform, was detected in one sample from the upstream location, and two additional VOCs, 2-butanone and trichloroethene were detected in two different samples from the downstream location (Table 3-2).

3.1.2 Sediment

Sediment samples collected during the 1989 investigation include discrete and composite sediment samples from SWMUs 9, 10, and 11 and sediment samples from the Walnut River upstream of the Site, at the NPDES outfall, and downstream of the Site. Sediment samples collected from the Evaporation Ponds No. 1 through No. 3 in 1990 were submitted for a limited suite of analyses, including chromium, lead, BTEX, and several PAHs. All of these analytes were detected in at least one Evaporation Pond. Barium, chromium, lead, di-n-butylphthalate, and xylenes were detected at all three river sample locations in 1989; benzene and xylene were detected at the outfall sample location, and chlorobenzene, ethylbenzene, and xylene were detected at the upstream sample location. Detection limits for some organic compounds were elevated in these 1989 and 1990 data (Table 3-4).

During the Phase II RFI, three samples were collected from the top six inches of sediment in each of SWMUs 9, 10, and 11. Each sample was submitted for VOC and SVOC analyses based on field screening with an organic vapor analyzer. The sample with the highest field screening photoionization detector (PID) result was selected for analysis. The sample submitted for metals analysis was a composite of three discrete samples from within each SWMU. Detected analytes include metals, VOCs, and SVOCs, including PAHs (Table 3-3). Walnut River sediment sampling was not included in the Phase II RFI.

3.2 DATA EVALUATION / DATA GAP RECOMMENDATIONS

Minimum criteria for analytical results to be usable for risk assessment are presented in EPA (1992a). These include requirements for complete data reporting (i.e., sample location, field data and meteorological data), and complete data documentation (i.e., chain of custody records, standard operating procedures, and field notes). The sample collection, preparation, and analytical methods should appropriately identify the constituent form or species; and the specified sample detection limit should be at or below a concentration that is associated with toxicologically relevant levels (e.g., published risk-based screening levels or action levels). Non-detect results with reporting limits greater than the toxicologically relevant levels are not suitable for risk assessment; the significance of any analytical detection limits greater than such criteria will be evaluated on a case-by-case basis and will be described in the Uncertainty Analysis section of the baseline HHRA Report for surface water and sediment. EPA (1992a) further requires that data quality indicators be included in the sampling plan at a level sufficient to determine data usability. According to USEPA (1989a), only data collected and analyzed at a quality control (QC) level equivalent to USEPA Level III or higher (USEPA, 1988), meets appropriate usability criteria for evaluation in a quantitative HHRA. USEPA Level III data provide the following:

- Low detection limits
- A wide range of calibrated analyses
- Matrix recovery information
- Laboratory process control information
- Known precision and accuracy

In addition to the data quality objectives listed above, it is necessary to obtain a sufficient quantity of data to estimate potential exposure concentrations. The number of samples required to adequately characterize an exposure area depends on the size of the area and the heterogeneity of the media and potential contamination. The usability of the existing surface water and sediment data for the Site, and requirements for additional data, are described briefly below.

3.2.1 Surface Water

Evaporation Ponds 1, 2, and 3 (SWMUs 9, 10, and 11) and Stormwater Pond (SWMU 23)

Surface water sampling data for the evaporation ponds and the stormwater pond are only available for a limited analyte list and for one sample each from SWMUs 9 and 11, and these data are more than 20 years old. Historic data indicate that potentially Site-related chemicals have been detected, but do not meet the data quality requirements for inclusion in the HHRA for surface water and sediment. Therefore, surface water in SWMUs 9, 10, 11, and 23 should be sampled. The stormwater ponds are dry most of the year, so sampling will occur in the winter. Total surface area for the ponds is between 7,500 and 10,000 square feet, however, surface area of the actual water in the ponds may be less. A minimum of one location will be sampled at two to three depths (i.e., surface, midway in the water column, and bottom of the pond), depending on the depth of the pond. Samples will be analyzed for metals, VOCs, and SVOCs. Details of the sample locations, sampling procedures and analytical methods will be described in the Surface Water and Sediment Investigation Work Plan.

Walnut River Surface Water

Surface water samples were collected from three locations in the 1990 Surface Water and Sediment Characterization and the 1999 Phase II RFI; upstream of the Site, at the NPDES outfall and at the downstream corner of the Site. Sampling results from both 1989 and 1999 did not indicate that potential contaminants were present at higher concentrations at the NPDES outfall or down gradient of the Site, compared with upgradient sample results. Additionally, attributing detected concentrations of analytes in surface water in the Walnut River, even during low flow conditions, to historic sediment impacts associated with the Site will be difficult. At the request of the Agencies, however, surface water samples will be collected from the Walnut River. Historic surface water sampling data from the Walnut River do not meet the data quality requirements for inclusion in the HHRA for surface water and sediment; results from these samples will be replaced by new surface water samples to be collected upstream of the Site, near the NPDES outfall, and downstream of the Site. The surface water samples should be analyzed for metals, VOCs and SVOCs. Details of the sample locations, sampling procedures and analytical methods will be described in the Surface Water and Sediment Investigation Work Plan.

3.2.2 Sediment

Evaporation Ponds 1, 2, and 3 (SWMUs 9, 10, and 11) and Stormwater Pond (SWMU 23)

Sediment data are only available for a few locations from each pond; the data for SWMU 23 consists of the shallow soil results from a soil boring presented in the 1992 Final RFI Report. Data from these samples do not meet the data quality requirements for inclusion in the HHRA for surface water and sediment; therefore, sediment sampling is recommended for all ponds. Composite samples will be collected according to guidelines for ponds 10,000 square feet and under from KDHE (1996). Five composite samples will be collected from each pond in order to characterize current and future exposures to surface sediment, and future exposures to deeper sediment during potential excavation. Composite samples will be collected from the pond bottom from 0-2 inches and 0-2 feet below ground surface. The pond bottom composite samples will include discrete samples from each of the four quadrants in the pond bottom. One composite sample will include four discrete samples from the pond sides, and two composite samples will include discrete samples from the pond inlets and outlets from 0-2 inches bgs and 0-2 feet bgs. Samples will be analyzed for metals, VOCs, and SVOCs. Details of the sample locations, sampling handling procedures, including sample compositing and selection of a representative sample for VOC analysis, and analytical methods will be described in the Surface Water and Sediment Investigation Work Plan; samples for VOC analysis will not be composited.

Walnut River Sediment

Off-Site sediment data from locations upstream, at the NPDES outfall, and downstream of the Site are available from 1989 only. These sample results include few detections and no clear pattern to indicate Site-related impacts. Additionally, access to sediment at the location of historically observed hydrocarbon seeps are no longer available due to river realignment and raising of the levee by the USACE. In 1998 and 1999 remedial measures were implemented in the areas where hydrocarbon seeps were observed. These remedial measures were implemented before the USACE river realignment and levee improvements. These remedies subsequently stopped the hydrocarbon seeps. Historic sediment sampling results do not meet the data quality requirements for inclusion in the HHRA for surface water and sediment and are not applicable to current conditions, and therefore these data are included for historical reference only.

To verify the current river sediment quality, sediment samples will be collected from the Walnut River upstream of the Site, at the NPDES outfall, and downstream of the site. The sediment samples should be analyzed for metals, VOCs and SVOCs. Details of the sample locations, sampling procedures and analytical methods will be described in the Surface Water and Sediment Investigation Work Plan.

4.0 HUMAN HEALTH RISK ASSESSMENT APPROACH

The methods to be used in the baseline HHRA for surface water and sediment are described in this section.

4.1 CONCEPTUAL SITE MODEL

The HHRA begins with the development of a site-specific conceptual site model (CSM). The site-specific CSM includes the identification of sources of contaminated media and constituents of potential concern (COPCs), evaluation of contaminant fate and transport pathways, potentially exposed populations, and potentially complete exposure pathways between contaminated media and receptors.

The following subsections describe methods to be used in the identification of medium-specific COPCs and the development of a site-specific CSM for the Site.

4.1.1 Contaminated Media and COPC Selection

Impacted media at the Site include surface and subsurface soil, groundwater, surface water and sediment. Soil and groundwater are evaluated in a separate HHRA (MWH, 2014). Although exposures associated with surface water and sediment are different than standard scenarios for soil or potable groundwater, identification of COPCs in surface water and sediment will be conducted in accordance with USEPA guidance. All analytical results (i.e., maximum detected concentration for detected analytes and maximum reporting limit for non-detect analytes) will be screened against the most current version of the USEPA's biannually updated Regional Screening Levels (RSLs) (USEPA, 2014a) for tap water and industrial soil exposures. According to USEPA (2009a), when more than one constituent is present in a Site medium, it is appropriate to consider the potential for cumulative effects from all detected constituents in that medium. This is because a constituent may be present at a maximum concentration that is lower than its respective screening level, but still contribute to a *cumulative* carcinogenic risk or noncarcinogenic hazard index (HI) that is greater than acceptable risk management criteria due to impacts of multiple constituents on a given toxicological endpoint. Cumulative effects screening is achieved by utilizing the version of the RSL Table developed for a target hazard quotient of 0.1 and a target risk of $1x10^{-6}$. The target hazard quotient of 0.1 is a factor of 10 less than the KDHE point of departure of 1; the cumulative lifetime cancer risk of 1×10^{-6} is already 10 times lower than the KDHE point of departure of 1×10^{-5}, and is therefore adequate for cumulative effects screening.

Analytes in surface water or sediment that are not related to refinery operations with a maximum detected concentration or an MDL or MRL below their respective screening level will be excluded from further evaluation in the baseline HHRA. Results for non-detect analytes with a MDL or MRL greater than their respective screening level will be evaluated on an analyte-specific basis. Analytes that are related to Site operations will be evaluated in the baseline HHRA even if they were not detected in surface water or sediment at concentrations greater than their respective screening levels.

Proposed surface water and sediment COPC screening values for use at the Site are presented in Table 3-1 through Table 3-4, respectively; these values are based on the current version of the RSLs (USEPA, 2014a) and will be updated for the HHRA Report, as appropriate. Formal COPC selection based on current RSLs will be presented in the HHRA Report, following additional characterization work.

4.1.2 Human Health CSM

The CSM describes the nature of contaminant sources, current and future human receptors that may be present and the potential for complete exposure pathways between contaminant sources and receptors (USEPA, 1989a; 1989b). The CSM for current and hypothetical future human receptors is depicted graphically in Figure 4-1 and described below.

4.1.2.1 Contamination Sources and Transport Pathways

Sources of soil contamination at the Site include historic spills and leaks from ASTs, process equipment, and SWMUs in the Process Area, leaching of metals and petroleum materials from decommissioned equipment in the Junk Storage Area, releases from SWMUs in the Construction Debris Landfill, and releases associated with tanks and SWMUs in the Former Tank Farm. Contaminants in soil may have volatilized to ambient air or been transported as windblown dust to other land or water areas. Site-related contaminants in soil that have infiltrated over time to the water table could seep into construction or utility trenches or discharge to off-Site surface water. Treated groundwater is discharged in to active on-Site treatment ponds and the Walnut River.

4.1.2.2 Potential Receptors

Current use of the property is limited to a small asphalt terminal consisting of a loading area and three in service ASTs. Additionally, the Site has a security fence and closed gate. It is assumed that all parcels will be redeveloped for commercial or industrial use, consistent with current land use and zoning. It is further assumed that agricultural land use or other growth of edible plants for human consumption will be prohibited. These assumptions will be supported by future land use controls (LUCs) and/or deed restrictions, as necessary.

The Site is located adjacent to a residential area, a sports park, the Kaw Wildlife Area, and the Arkansas and Walnut Rivers. However, transport of contaminants as windblown dust is likely to be minimal, and treated water discharged to the Walnut River meets NPDES requirements. Therefore, the only likely route for off-Site transport is with groundwater discharge to the Walnut River in the absence of the groundwater capture and treatment system. Impacted off-Site sediment from historic discharges to the Walnut River prior to installation of the treatment system has been covered or separated from the current river channel by modifications to the Army Corps' levee.

Potentially exposed receptors include current and future on-Site commercial or industrial workers (i.e., existing Site MRP employees, and future commercial/industrial workers following redevelopment of the Site), future construction or utility workers, current and future on-Site trespassers, and current and future off-Site recreational users of the Walnut River. Off-Site receptors are not likely to be exposed to Site-related contamination, due to the limited potential for off-Site transport described above; however, exposure of current and future recreational users will conservatively be evaluated. Minimal work occurs at or near the stormwater ponds currently, and therefore exposure assumptions associated with future commercial or industrial workers will be protective of current commercial or industrial workers. Additionally, the evaluation of future commercial/industrial workers will be protective of any on-Site trespassers. Exposures associated with future on-Site construction work are likely to be protective of any minimal utility work that would occur in or near the stormwater ponds and the exposure parameters for the future construction/utility worker receptor will be based on hypothetical exposures that might occur during construction. Therefore, the three receptors to be quantitatively evaluated in the HHRA for surface water and sediment are future on-Site outdoor commercial or industrial workers, future on-Site construction or utility workers, and current / future off-Site recreational users.

Potentially Complete Exposure Pathways for On-Site Receptors

Current/future commercial or industrial workers and future construction or utility workers may be exposed to contaminated surface water via incidental ingestion and dermal contact. Concentrations of surface water derived volatile compounds in outdoor ambient air are likely to be insignificant, and therefore this exposure pathway is complete but insignificant. As noted previously, the stormwater ponds are only seasonally wet; therefore the exposure frequency for surface water will be limited to a fraction of the year. Exposure to sediment contamination may occur via incidental ingestion of, and dermal contact with contaminated sediment, and, during period when the ponds are dry, inhalation of volatile contaminants in sediment and nonvolatile contaminants adsorbed to wind-blown dust. Current and future workers at a commercial or industrial site are potentially exposed to media in stormwater ponds while mowing, cutting vegetation, or otherwise maintaining the ponds perimeter. Such grounds keeping work currently occurs once per week during the months of April through September, and would result in exposure of Site workers to surface sediment (i.e., the top two inches bgs). Future construction and utility workers are potentially exposed to media in stormwater ponds while expanding or otherwise modifying the ponds, or in the process of redeveloping the location of a former pond. Although this work would likely take place when the pond was dry, surface water exposure is conservatively evaluated for this receptor. Future on-Site construction/utility workers are assumed to be exposed to sediment from ground surface to two feet bgs. Deeper excavation during construction is not expected because the bottoms of the stormwater ponds are already close to the water table.

Potentially Complete Exposure Pathways for Off-Site Receptors

Off-Site receptors exposed to surface water and sediment in the Walnut River include people boating, swimming, and fishing. The portion of the Walnut River adjacent to the Site is not developed for swimmers or non-fishing recreational boaters; therefore the most highly exposed potential off-Site receptor is a person recreationally fishing. This receptor might be incidentally exposed to surface water, surface sediment from zero to two inches bgs, and fish that have accumulated contaminants from sediment and surface water. Concentrations of surface water derived volatile compounds in outdoor ambient air are likely to be insignificant, and therefore this exposure pathway is complete but insignificant. Inhalation of sediment derived volatile constituents and non-volatile constituents adsorbed to dust is an incomplete pathway for the off-Site recreational receptor because potentially contaminated sediment is continually inundated. Although wading in the portion of the Walnut River located adjacent to the Site is unlikely, exposure parameters for the recreational receptor will conservatively assume that this receptor wades in to the river barefoot while fishing. Additionally, because child incidental ingestion rates and soil adherence factors result in higher doses than adult exposure rates, noncancer effects characterization will be based on an adolescent (i.e., 6 to 11 year old) recreational receptor. Cancer risk estimates are based on cumulative exposure over the entire lifetime, and therefore the dose estimates for carcinogenic chemicals will be based on a composite adolescent and adult recreational receptor.

4.2 BASELINE HUMAN HEALTH RISK ASSESSMENT METHODS

The baseline HHRA for the Site will be performed in accordance with the following USEPA guidance documents:

- Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual, Part A (USEPA, 1989a).
- Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual, Part D, Standardized Planning, Reporting, and Review of Superfund Risk Assessments (USEPA, 2001).
- Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988).
- Final Exposure Assessment Guidelines (USEPA, 1992b).
- Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (USEPA, 2002).
- Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual, Part E, Supplemental Guidance for Dermal Risk Assessment (USEPA, 2004).
- Risk Assessment Guidance for Superfund (RAGS), Volume 1: Human Health Evaluation Manual, Part F, Supplemental Guidance for Inhalation Risk Assessment (USEPA, 2009a).
- Exposure Factors Handbook: 2011 Edition (USEPA, 2011a).

The general framework for conducting baseline HHRAs is provided in USEPA's *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, Part A. Baseline Risk Assessment* (USEPA, 1989a). Consistent with these guidance documents, the baseline HHRA consists of the following five steps:

1. Exposure assessment
2. Data evaluation and exposure quantification
3. Toxicity assessment
4. Risk characterization
5. Uncertainty analysis

4.2.1 Exposure Assessment

The exposure assessment begins with development of a site-specific CSM; the human health CSM for the Site was described in Section 4.1.

Potential human receptors to be evaluated in the HHRA for surface water and sediment are future industrial or commercial workers, future utility or construction workers, and current and future off-Site recreational users, as described in Section 4.1.2.2. Potentially complete exposure pathways for these receptors are presented graphically in Figure 4-1.

4.2.2 Data Evaluation and Exposure Quantification

Prior to use in risk and hazard quantification, site data are evaluated for quality and usability according to the methods in Section 3.2. Data of adequate quality are screened as described in Section 4.1.1 to identify COPCs.

Potential exposures and risks associated with the complete exposure pathways identified in Section 4.1.2.2 will be quantified according to the procedures described below. Methods to be used in the derivation of exposure point concentrations (EPCs), and procedures for quantifying theoretical exposure doses, are described in the following subsections. As described previously, likely future land uses for the Site with the highest potential for human exposure include industrial facilities or business parks where significant portions of the properties are unpaved and left barren and/or landscaped. Due to compaction of Site soils, continued use of the existing retention basins to contain stormwater runoff is expected in a future industrial or commercial scenario. Additionally, the surface water stage of the groundwater treatment system is expected to remain unchanged in the near future.

Surface water and sediment exposures will be quantified separately for each stormwater retention pond. As described in Section 3.2, the number of samples used to calculate surface water EPCs will be determined based on the estimated volume and heterogeneity of the water in the pond. Sediment EPCs will be based on results of three composite samples from each pond. Sediment sample locations will not be limited to the current wetted area of the pond at the time of sampling, but instead will encompass all potentially contaminated material.

4.2.2.1 Calculating Exposure Doses

Exposure doses will be calculated according to methods and intake equations presented in USEPA's *Risk Assessment Guidance for Superfund* (RAGS; USEPA, 1989a). Equations for quantifying incidental ingestion, dermal contact, and inhalation exposures to COPCs in soil are presented below. Exposure parameters used in dose modeling are presented in Table 4-1. For the current/future recreational receptor exposed to carcinogenic chemicals, the exposure dose equations are modified to include an age-adjusted factor that combines the dose assumptions for adolescent and adult receptors in to a single factor that incorporates age specific exposure parameters such as body weight, ingestion rate, and exposure duration. As described in Section 4.1.2.2, a child or adolescent is the most conservative receptor for evaluation of the effects of non-carcinogenic chemicals, and therefore an age adjusted intake is not used for these chemicals.

The composite dose equation and age-adjusted factor for current/future recreational receptors is listed after the single-age dose equation for each medium.

Incidental Ingestion of Sediment

$$\text{Ingestion Intake for Sediment}\left(\frac{\text{mg}}{\text{kg} \times \text{day}}\right) = \frac{\text{CS} \times \text{IR} \times \text{CF} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

Where:

- CS = concentration in sediment (milligrams per kilogram [mg/kg])
- IR = ingestion rate (mg sediment/day)
- CF = conversion factor (10^{-6} kilograms per milligram [kg/mg])
- EF = exposure frequency (days/year)
- ED = exposure duration (years)
- BW = body weight (kilogram [kg])
- AT = averaging time (period over which exposure is averaged – days)

Incidental Ingestion of Sediment for Composite Adolescent and Adult Receptors

$$\text{Composite Ingestion Intake for Sediment}\left(\frac{\text{mg}}{\text{kg} \times \text{day}}\right) = \frac{\text{CS} \times \text{IF}_{\text{sed}} \times \text{CF}}{\text{AT}}$$

Where:

$$\text{IF}_{\text{sed}}\left(\frac{\text{mg}}{\text{kg}}\right) = \frac{\text{IR}_{adolescent} \times \text{ED}_{adolescent} \times EF_{adolescent}}{BW_{adolescent}} + \frac{\text{IR}_{adult} \times \text{ED}_{adult} \times EF_{adult}}{BW_{adult}}$$

and

- CS = concentration in sediment (mg/kg)
- IF_{sed} = age adjusted sediment ingestion factor (mg/kg)
- CF = conversion factor (10^{-6} kg/mg)
- AT = averaging time (period over which exposure is averaged – days)
- $IR_{adolescent}$ = adolescent ingestion rate (mg sediment/day)
- IR_{adult} = adult ingestion rate (mg sediment/day)
- $ED_{adolescent}$ = adolescent exposure duration (years)
- ED_{adult} = adult exposure duration (years)
- $EF_{adolescent}$ = adolescent exposure frequency (days/year)
- EF_{adult} = adult exposure frequency (days/year)
- $BW_{adolescent}$ = adolescent body weight (kg)
- BW_{adult} = adult body weight (kg)

As described in Section 4.2.3.1 below, if arsenic is identified as a COPC, the oral dose will be adjusted by the relative bioavailability (RBA) of 60% for arsenic.

Dermal Contact with Sediment

$$\text{Dermal Contact with Sediment}\left(\frac{\text{mg}}{\text{kg}\times\text{day}}\right)=\frac{\text{CS}\times\text{CF}\times\text{SA x AF}\times\text{ABS}\times\text{EF}\times\text{ED}}{\text{BW}\times\text{AT}}$$

Where:

CS = concentration in sediment (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
SA = skin surface area exposed (square centimeters [cm^2])
AF = adherence factor of sediment (milligrams per square centimeter per day [mg/cm^2-day])
ABS = skin absorption factor (unitless)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (period over which exposure is averaged – days)

Dermal Contact with Sediment for Composite Adolescent and Adult Receptors

$$\text{Composite Dermal Contact with Sediment}\left(\frac{\text{mg}}{\text{kg}\times\text{day}}\right)=\frac{\text{CS}\times\text{DF}_{\text{sed}}\times\text{ABS}\times\text{CF}}{\text{AT}}$$

Where:

$$\text{DF}_{\text{sed}}\left(\frac{\text{mg}}{\text{kg}}\right)=\frac{\text{AF}_{\text{adolescent}}\times\text{SA}_{\text{adolescent}}\times\text{ED}_{\text{adolescent}}\times\text{EF}_{\text{adolescent}}}{\text{BW}_{\text{adolescent}}}+\frac{\text{AF}_{\text{adult}}\times\text{SA}_{\text{adult}}\times\text{ED}_{\text{adult}}\times\text{EF}_{\text{adult}}}{\text{BW}_{\text{adult}}}$$

and

CS = concentration in sediment (mg/kg)
DF_{sed} = age adjusted sediment dermal factor (mg/kg)
ABS = skin absorption factor (unitless)
CF = conversion factor (10-6 kg/mg)
AT = averaging time (period over which exposure is averaged – days)
$AF_{adolescent}$ = adolescent adherence factor for sediment (mg/cm^2-day)
AF_{adult} = adult adherence factor for sediment (mg/cm^2-day)
$SA_{adolescent}$ = adolescent skin surface area exposed (cm^2)
SA_{adult} = adult skin surface area exposed (cm^2)
$ED_{adolescent}$ = adolescent exposure duration (years)
ED_{adult} = adult exposure duration (years)
$EF_{adolescent}$ = adolescent exposure frequency (days/year)
EF_{adult} = adult exposure frequency (days/year)
$BW_{adolescent}$ = adolescent body weight (kg)
BW_{adult} = adult body weight (kg)

Incidental Ingestion of Surface Water:

$$\text{Incidental Ingestion Intake for Surface Water}\left(\frac{\text{mg}}{\text{kg}\times\text{day}}\right)=\frac{\text{CW}\times\text{IR}\times\text{CF}\times\text{ET}\times\text{EF}\times\text{ED}}{\text{BW}\times\text{AT}}$$

Where:

CW = concentration in water (mg/L)
IR = ingestion rate (milliliters per hour [mL/hour])
CF = conversion factor (L/mL)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = averaging time (period over which exposure is averaged – days)

Incidental Ingestion of Surface Water for Composite Adolescent and Adult Receptors

$$\text{Composite Ingestion Intake for Surface Water}\left(\frac{\text{mg}}{\text{kg}\times\text{day}}\right)=\frac{\text{CW}\times\text{IF}_{\text{sw}}\times\text{CF}}{\text{AT}}$$

Where:

$$\text{IF}_{\text{sw}}\left(\frac{\text{mL}}{\text{kg}}\right)=\frac{\text{IR}_{\text{adolescent}}\times\text{ED}_{\text{adolescent}}\times\text{EF}_{\text{adolescent}}\times\text{ET}_{\text{adolescent}}}{\text{BW}_{\text{adolescent}}}+\frac{\text{IR}_{\text{adult}}\times\text{ED}_{\text{adult}}\times\text{EF}_{\text{adult}}\times\text{ET}_{\text{adult}}}{\text{BW}_{\text{adult}}}$$

and

CW = concentration in surface water (mg/L)
IF_{sw} = age adjusted surface water ingestion factor (mL/kg)
CF = conversion factor (10^{-6} L/mL)
AT = averaging time (period over which exposure is averaged – days)
$IR_{adolescent}$ = adolescent ingestion rate (mL/hour)
IR_{adult} = adult ingestion rate (mL/hour)
$ED_{adolescent}$ = adolescent exposure duration (years)
ED_{adult} = adult exposure duration (years)
$EF_{adolescent}$ = adolescent exposure frequency (days/year)
EF_{adult} = adult exposure frequency (days/year)
$ET_{adolescent}$ = adolescent exposure time (hours/day)
ET_{adult} = adult exposure time (hours/day)
$BW_{adolescent}$ = adolescent body weight (kg)
BW_{adult} = adult body weight (kg)

Dermal Contact with Surface Water:

The dermally absorbed dose for some chemicals is not high enough to warrant inclusion in the total dose calculation. Organic and inorganic COPCs in surface water will be screened according to Exhibit B-3 and Exhibit B-4, respectively, in USEPA (2004).

$$\text{Dermal Contact with Surface Water}\left(\frac{\text{mg}}{\text{kg} \times \text{day}}\right) = \frac{\text{CW} \times \text{CF} \times \text{ED} \times \text{EF} \times \text{ET} \times \text{SA} \times \text{Kp}}{\text{BW} \times \text{AT}}$$

Where:

CW	=	concentration in surface water (mg/L)
CF	=	conversion factor (10-3 L/cm3)
ED	=	exposure duration (years)
EF	=	exposure frequency (days/year)
ET	=	dermal exposure time (hours/day)
SA	=	skin surface area exposed (cm2)
Kp	=	dermal permeability constant (cm/hour)
BW	=	body weight (kg)
AT	=	averaging time (period over which exposure is averaged – days)

Dermal Contact with Surface Water for Composite Adolescent and Adult Receptors

$$\text{Composite Dermal Contact with Surface Water}\left(\frac{\text{mg}}{\text{kg} \times \text{day}}\right) = \frac{\text{CW} \times \text{CF} \times \text{DF}_{\text{sw}} \times \text{ET} \times \text{Kp}}{\text{AT}}$$

Where:

$$\text{DF}_{\text{sw}}\left(\frac{\text{cm}^2 \times \text{day}}{\text{kg}}\right) = \frac{\text{SA}_{\text{adolescent}} \times \text{ED}_{\text{adolescent}} \times \text{EF}_{\text{adolescent}}}{\text{BW}_{\text{adolescent}}} + \frac{\text{SA}_{\text{adult}} \times \text{ED}_{\text{adult}} \times \text{EF}_{\text{adult}}}{\text{BW}_{\text{adult}}}$$

and

CW	=	concentration in surface water (mg/L)
CF	=	conversion factor (10^{-3} L/cm^3)
DF_{sw}	=	age adjusted surface water dermal factor (cm^2 x day/kg)
ET	=	dermal exposure time (hours/day)
Kp	=	dermal permeability constant (cm/hour)
AT	=	averaging time (period over which exposure is averaged – days)
$SA_{adolescent}$	=	adolescent skin surface area exposed (cm^2)
SA_{adult}	=	adult skin surface area exposed (cm^2)
$ED_{adolescent}$	=	adolescent exposure duration (years)
ED_{adult}	=	adult exposure duration (years)
$EF_{adolescent}$	=	adolescent exposure frequency (days/year)
EF_{adult}	=	adult exposure frequency (days/year)
$BW_{adolescent}$	=	adolescent body weight (kg)
BW_{adult}	=	adult body weight (kg)

Inhalation of Ambient Air:

$$\text{Noncancer Inhalation of COPCs in Dry Sediment } \left(\frac{mg}{m^3}\right) = \frac{CS \times (\frac{1}{PEF} \text{ or } \frac{1}{VF}) \times EF \times ED \times ET}{AT}$$

Where:

- CS = concentration in sediment (mg/kg)
- PEF = particulate emission factor (m^3/kg)
- VF = volatilization factor (m^3/kg)
- EF = exposure frequency (days/year)
- ED = exposure duration (years)
- ET = exposure time (unitless; hours per 24 hour day)
- AT = averaging time (period over which exposure is averaged – days)

The inhalation exposure concentration for carcinogenic COPCs will include an additional conversion factor of 1,000 micrograms (µg) per milligram, such that the units of the exposure concentration are µg/m^3. Inhalation pathways are incomplete for current/future off-Site recreational receptors, and therefore no composite inhalation dose equation is necessary.

Modeling parameters for Lincoln Nebraska presented in Appendix D of USEPA (2002) and pond-specific areas will be used to calculate pond-specific PEFs for calculation inhalation exposure concentrations for future commercial or industrial workers. The pond-specific PEFs used to calculate inhalation exposures for future construction or utility workers will be calculated according to the pond-specific area, and models and parameters presented in Appendix E of USEPA (2002).

Ingestion of Fish:

$$\text{Ingestion of Fish } \left(\frac{mg}{kg \times day}\right) = \frac{C_{fish} \times IR \times ED \times EF \times CF}{BW \times AT}$$

Where:

- C_{fish} = concentration of contaminant in fish (mg/kg)
- IR = fish ingestion rate (mg / day)
- CF = conversion factor (10^{-6} kg/mg)
- ED = exposure duration (years)
- EF = exposure frequency (days/year)
- BW = body weight (kg)
- AT = averaging time (period over which exposure is averaged – days)

Fish tissue concentration will be modeled from sediment data using bioaccumulation factors.

Ingestion of Fish for Composite Adolescent and Adult Receptors

$$\text{Composite Ingestion Intake for Fish } \left(\frac{mg}{kg \times day}\right) = \frac{C_{fish} \times IF_{fish} \times CF}{AT}$$

Where:

$$IF_{fish}\left(\frac{mg}{kg}\right) = \frac{IR_{adolescent} \times ED_{adolescent} \times EF_{adolescent}}{BW_{adolescent}} + \frac{IR_{adult} \times ED_{adult} \times EF_{adult}}{BW_{adult}}$$

and

C_{fish} = concentration in fish (mg/kg)
IF_{fish} = age adjusted fish ingestion factor (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
AT = averaging time (period over which exposure is averaged – days)
$IR_{adolescent}$ = adolescent ingestion rate (L /day)
IR_{adult} = adult ingestion rate (L /day)
$ED_{adolescent}$ = adolescent exposure duration (years)
ED_{adult} = adult exposure duration (years)
$EF_{adolescent}$ = adolescent exposure frequency (days/year)
EF_{adult} = adult exposure frequency (days/year)
$BW_{adolescent}$ = adolescent body weight (kg)
BW_{adult} = adult body weight (kg)

4.2.3 Toxicity Assessment

The human health toxicity assessment will be performed in accordance with EPA Guidance (USEPA, 1989a). The primary sources of toxicity values to be used in the baseline HHRA will be follows:

- Integrated Risk Information System (IRIS) Database (USEPA, 2014b).
- USEPA RSL Table, May, 2014 (USEPA, 2014a).
- Provisional Peer Reviewed Toxicity Values (PPRTV) (USEPA, 2014d).
- Health Effects Assessment Summary Tables (HEAST) (USEPA, 1997a).
- Other USEPA documents, as applicable.
- California Environmental Protection Agency Toxicity Criteria Database (OEHHA, 2014).

4.2.3.1 Constituent-Specific Assumptions

Dermal Toxicity

Although the USEPA has developed toxicity criteria for the oral and inhalation routes of exposure, toxicity criteria for the dermal route of exposure have not been developed. USEPA has proposed a method for extrapolating oral toxicity criteria to the dermal route in *Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment)* (USEPA, 2004). This USEPA guidance states that the adjustment of the oral toxicity factor for dermal exposures is necessary only when the oral-gastrointestinal absorption efficiency of the constituent of interest is less than 50 percent (due to the variability inherent in absorption studies).

Adjustment of oral toxicity criteria to derive dermal reference doses (RfDs) and cancer slope factors (CSFs) will be conducted as follows:

$$\text{Dermal RfD} = \text{Oral RfD} \times ABS_{GI}$$
$$\text{Dermal CSF} = \text{Oral CSF}/ABS_{GI}$$

Where:

ABS_{GI} = oral absorption efficiency
CSF = cancer slope factor
RfD = reference dose

For constituents lacking an oral-gastrointestinal absorption efficiency value, the oral absorption efficiency is assumed to be 100 percent and the oral RfD or CSF will be used to estimate toxicity via the dermal route.

Lead Toxicity

Cause-and-effect relationships in humans have been correlated with concentrations of lead in blood. Therefore, at sites where lead is identified as a COPC, the preferred risk assessment approach is the estimation of human blood-lead concentrations associated with an exposure situation. If lead is identified as a COPC at the Site, the Adult Lead Model (USEPA, 2009b) will be used to predict blood-lead levels for future commercial or industrial and utility or construction workers exposed to lead in soil.

Arsenic Bioavailability

The USEPA has established a RBA of 60% for arsenic in soil relative to arsenic in water to account for differences in absorption between the readily soluble forms of the chemical ingested with water and the chemical ingested with site media (USEPA, 2012). The reduced dose of arsenic resulting from soil exposures compared to water exposures does not affect the derived oral toxicity values for arsenic, but will be applied to the calculated dose from soil ingestion.

4.2.4 Risk Characterization

Risk characterization integrates the results of exposure and toxicity assessments to derive a quantitative evaluation of potential risks to current and future human receptors. Risk of developing cancer and the potential for noncancer effects are quantified separately by calculating an incremental lifetime cancer risk (ILCR) and hazard quotient (HQ), respectively, as described below.

Analyte-specific cancer risk estimates will be calculated as the sum of all applicable individual pathways for each receptor. The pathway and analyte specific risk is equal to the product of the dose and the cancer toxicity value (USEPA, 1989a):

$$\text{ILCR} = \text{Dose [or concentration]} \times \text{CSF [or IUR]}$$

Where:

ILCR	=	incremental lifetime carcinogenic risk (unitless)
CSF	=	carcinogenic slope factor $(mg/kg\text{-}day)^{-1}$
IUR	=	inhalation unit risk $(\mu g/m^3)^{-1}$
Concentration	=	exposure concentration $(\mu g/m^3)$
Dose	=	exposure dose (mg/kg-day)

Analyte-specific non-cancer hazard estimates will be calculated as the sum of all applicable individual pathways for each receptor. The pathway and analyte specific hazard is equal to the ratio of the dose to the non-cancer toxicity value (USEPA, 1989a):

$$HQ = \frac{\text{Dose [or concentration]}}{\text{RfD [or RfC]}}$$

Where:

HQ	=	hazard quotient (unitless)
Concentration	=	exposure concentration (mg/m^3)
Dose	=	exposure dose (mg/kg-day)
RfC	=	reference concentration (mg/m^3)
RfD	=	reference dose (mg/kg-day)

Analyte-specific ILCR and HQ estimates will be summed to cumulative media- and exposure area-specific ILCR and hazard index (HI) estimates for each pond and the Walnut River. Cumulative surface water and sediment ILCR and HI estimates will then be summed for cumulative exposure area-specific cancer risk and noncancer hazard estimates.

The EPA considers a cancer risk between 1×10^{-6} and 1×10^{-4} and a noncancer HI of 1 as the point of departure for making risk management decisions concerning a site. Sites with associated cumulative cancer risk and noncancer HI estimates that exceed these criteria are proposed for further evaluation, or consideration of remedial alternatives. Previous agreement between EPA, KDHE, and MRP has set 1×10^{-5} as the cancer risk point of departure for this Site. Exposure Units with a cumulative cancer risk estimate below 1×10^{-5}, and a noncancer HI of less than 1, may be appropriate for conditional closure.

4.2.5 Uncertainty Analysis

Uncertainties are inherent in the risk assessment process and arise from limitations in the available information, analysis methods, and necessary assumptions. Sources of uncertainty may include chemical characterization information and limitations in the available data, assessment of potential exposures, and modeling of uptake and toxicity. Each of these sources of uncertainty, and any additional Site-specific uncertainties, will be described in the HHRA Report for surface water and sediment.

5.0 REFERENCES

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TABLES

Table 3-1
Available Characterization Data for On-Site Surface Water
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Surface Water Characterization Sample Results (1990) [b]	
		SWMU 9	SWMU 11
Metals			
Chromium	2,200	<5	82
Hexavalent chromium [c]	0.035	-	-
Lead	15	**<3**	**154.3**
Volatile Organic Compounds			
Benzene	0.45	**<1**	**<1**
Ethylbenzene	1.5	1.2	<1
Toluene	110	1.7	<1
Xylene	19	7.2	<1
Semi-volatile Organic Compounds			
Anthracene	180	-	<14
Chrysene	3.4	-	**<4**
Naphthalene	0.17	-	**<36**
Phenanthrene	-	-	**<12**

Notes:
All sample results and screening levels are presented in micrograms per liter (µg/L).

- = not applicable; analysis not performed or screening value not available for this chemical
< = analyte not detected; value shown is the detection limit
SWMU - solid waste management unit
µg/L - micrograms per liter

Bolding of a chemical name indicates that the screening level was exceeded by a detected concentration or detection limit; **bolding** of a value indicates that the screening level was exceeded by that value.

[a] United States Environmental Protection Agency Tap Water Regional Screening Levels (USEPA, 2014a). Screening levels for non-carcinogenic compounds are based on a hazard quotient (HQ) of 0.1.
[b] Results of surface water sampling of on-Site ponds, as reported in the Surface Water and Sediment Characterization Report (Total Petroleum, Inc.) dated 9/4/1990. No additional data have been collected for on-Site surface water.
[c] Speciated chromium analyses were not performed on historic samples; however surface water samples collected for the Human Health Risk Assessment will be analyzed for hexavalent chromium.

Table 3-2
Available Characterization Data for Surface Water in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Surface Water Characterization Sample Results (1990) [b]						Phase II RFI Surface Water Sample Results (1999) [c]					
		Upstream		NPDES Outfall		Downstream		Upstream		NPDES Outfall		Downstream	
		No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result
Metals													
Antimony	0.78	0	**<50**	0	**<50**	0	**<50**	0	**<5**	0	**<5**	0	**<5**
Arsenic	0.052	0	**<10**	0	**<10**	0	**<10**	1	**4.8**	2	**4.8**	3	**4.4**
Barium	380	1	300	2	**400**	2	**400**	3	169	3	166	3	196
Beryllium	2.5	-	-	-	-	-	-	2	0.39	2	0.58	1	0.90
Cadmium	0.92	0	**<10**	0	**<10**	0	**<10**	2	**1.0**	1	0.32	3	0.69
Chromium	2,200	0	<40	0	<40	0	<40	3	3.5	2	4.5	3	5.7
Hexavalent chromium [d]	0.035	-	-	-	-	-	-	-	-	-	-	-	-
Cobalt	0.6	0	**<50**	0	**<50**	0	**<50**	-	-	-	-	-	-
Cyanide	0.15	-	-	-	-	-	-	1	**2.2**	2	**1.4**	1	**1.4**
Lead	15	1	**63**	1	**32**	1	8	1	2.8	0	<8.7	1	9.2
Mercury	0.57	2	0.3	1	0.2	0	<0.2	2	0.14	2	0.29	1	0.13
Nickel	39	1	**140**	1	**130**	1	**80.0**	3	5.3	3	6.5	3	6.9
Selenium	10	0	<5	0	<5	0	<5	0	<2.9	0	<2.9	0	<2.9
Silver	9.4	-	-	-	-	-	-	0	<2	0	<2	0	<2
Vanadium	8.6	0	**<1000**	0	**<1000**	0	**<1000**	3	**11**	3	**10**	3	**15**
Zinc	600	-	-	-	-	-	-	3	53	2	17	2	25
Volatile Organic Compounds													
Acetone	1,400	0	<10	0	<10	0	<10	-	-	-	-	-	-
Benzene	0.45	0	<0.4	0	<0.4	0	<0.4	0	**<5**	0	**<5**	0	**<5**
2-Butanone	560	0	<50	0	<50	0	<50	0	<5	0	<5	1	2.0
Carbon disulfide	81	0	<10	0	<10	0	<10	0	<5	0	<5	0	<5
Carbon tetrachloride	0.45	0	**<0.7**	1	**3.3**	0	**<0.7**	-	-	-	-	-	-
Chlorobenzene	7.8	0	<0.4	0	<0.4	0	<0.4	0	<5	0	<5	0	<5
Chloroform	0.22	0	**<0.5**	0	**<0.5**	0	**<0.5**	1	**6.0**	0	**<5**	0	**<5**
1,2-Dibromoethane	0.0075	-	-	-	-	-	-	0	**<5**	0	**<5**	0	**<5**
1,2-Dichloroethane	0.17	0	**<0.6**	0	**<0.6**	0	**<0.6**	0	**<5**	0	**<5**	0	**<5**
1,1-Dichloroethene	28	-	-	-	-	-	-	0	<5	0	<5	0	<5
1,4-Dioxane	0.78	0	**<50**	0	**<50**	0	**<50**	0	**<500**	0	**<500**	0	**<500**
1,1-Dichloroethylene	28	0	<0.6	0	<0.6	0	<0.6	-	-	-	-	-	-
2,4-Dinitrotoluene	0.24	-	-	-	-	-	-	0	**<10**	0	**<10**	0	**<10**
Ethylbenzene	1.50	0	<0.7	0	<0.7	0	<0.7	0	**<5**	0	**<5**	0	**<5**
Ethyl Dibromide	-	0	**<1**	0	**<1**	0	**<1**	-	-	-	-	-	-
Styrene	120	0	<0.5	0	<0.5	0	<0.5	0	<5	0	<5	0	<5
Tetrachloroethene	4.1	-	-	-	-	-	-	0	**<5**	0	**<5**	0	**<5**
Toluene	110	1	5.5	1	6	0	<0.4	0	<5	0	<5	0	<5

Table 3-2
Available Characterization Data for Surface Water in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Surface Water Characterization Sample Results (1990) [b]						Phase II RFI Surface Water Sample Results (1999) [c]					
		Upstream		NPDES Outfall		Downstream		Upstream		NPDES Outfall		Downstream	
		No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result
1,1,1-Trichloroethane	800	-	-	-	-	-	-	0	<5	0	<5	0	<5
Trichloroethylene	0.28	1	**5.1**	1	**5.2**	1	**4.8**	0	**<5**	0	**<5**	1	**3.0**
1,2,4-Trimethylbenzene	1.5	-	-	-	-	-	-	0	**<5**	0	**<5**	0	**<5**
1,3,5-Trimethylbenzene	12	-	-	-	-	-	-	0	<5	0	<5	0	<5
Xylene	19	1	2	0	<0.6	1	0.6	0	<5	0	<5	0	<5
Semi-volatile Organic Compounds													
Anthracene	180	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Acenaphthene	53	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Benzenethiol	1.7	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Benzo(a)anthracene	0.034	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Benzo(b)fluoranthene	0.034	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Benzo(k)fluoranthene	0.34	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Benzo(a)pyrene	0.0034	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
bis(2-ethylhexyl)phthalate	5.6	0	<5	0	<5	0	<5	0	**<10**	0	**<10**	0	**<10**
Butylbenzylphthalate	16	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Chrysene	3.4	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Cresol-o	93	-	-	-	-	-	-	0	<10	0	<10	0	<10
Cresol-p	190	-	-	-	-	-	-	0	<10	0	<10	0	<10
Cresols	190	0	<5	0	<5	0	<5	-	-	-	-	-	-
Dibenz(a,h)anthracene	0.0034	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Dibenzofuran	0.79	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Dichlorobenzene	0.48	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
1,2-Dichlorobenzene	30	-	-	-	-	-	-	0	<10	0	<10	0	<10
1,3-Dichlorobenzene	0.48	-	-	-	-	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	0.48	-	-	-	-	-	-	0	**<10**	0	**<10**	0	**<10**
Diethylphthalate	1,500	0	<5	0	<5	0	<5	-	-	-	-	-	-
7,12-Dimethylbenz(a)anthracene	0.00010	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
2,4-Dimethylphenol	36	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Dimethylphthalate	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
2,4-Dinitrophenol	3.9	0	**<50**	0	**<50**	0	**<50**	-	-	-	-	-	-
Di-n-butylphthalate	90	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Di-n-octylphthalate	20	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Dinbz(a,h)acridine	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Fluoranthene	80	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Fluorene	29	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Indene	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-

Table 3-2
Available Characterization Data for Surface Water in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Surface Water Characterization Sample Results (1990) [b]						Phase II RFI Surface Water Sample Results (1999) [c]					
		Upstream		NPDES Outfall		Downstream		Upstream		NPDES Outfall		Downstream	
		No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result	No. of Detects	Result
Indeno(1,2,3-cd)pyrene	0.034	-	-	-	-	-	-	0	**<10**	0	**<10**	0	**<10**
Methyl chrysene	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
1-Methylnaphthalene	1.1	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
2-Methylnaphthalene	3.6	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Naphthalene	0.17	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Nitrobenzene	0.14	-	-	-	-	-	-	0	**<10**	0	**<10**	0	**<10**
4-Nitrophenol	-	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-
Phenanthrene	-	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Phenol	580	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Pyrene	12	0	<5	0	<5	0	<5	0	<10	0	<10	0	<10
Pyridine	2.0	0	**<5**	0	**<5**	0	**<5**	0	**<10**	0	**<10**	0	**<10**
Quinoline	0.024	0	**<5**	0	**<5**	0	**<5**	-	-	-	-	-	-

Notes:
All sample results and screening levels are presented in micrograms per liter (µg/L).

- = not applicable; analysis not performed or screening value not available for this chemical
< = analyte not detected; value shown is the detection limit
NPDES - National Pollutant Discharge Elimination System
RFI - Resource Conservation and Recovery Act Facility Investigation
µg/L - micrograms per liter

Bolding of a chemical name indicates that the screening level was exceeded by a detected concentration or detection limit; **bolding** of a value indicates that the screening level was exceeded by that value.

[a] United States Environmental Protection Agency Tap Water Regional Screening Levels (USEPA, 2014a). Screening levels for non-carcinogenic compounds are based on a hazard quotient (HQ) of 0.1.

[b] Maximum of two surface water samples collected from the surface and mid-depth in the water column on November 9, 1989, as reported in the Surface Water and Sediment Characterization Report (Total Petroleum, Inc.) dated 9/4/1990.

[c] Average detected concentration or maximum reporting limit from three samples collected upstream, at the NPDES outfall, and downstream of the Site on October 7, October 27, and November 8th, 1999.

[d] Speciated chromium analyses were not performed on historic samples; however surface water samples collected for the Human Health Risk Assessment will be analyzed for hexavalent chromium.

Table 3-3
Available Characterization Data for On-Site Sediment
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Historic Sample Results [b]				
		Number of Samples	Number of Detects	Detection Frequency (%)	Maximum Detection Limit for Non-Detects	Maximum Detected Concentration
Metals						
Antimony	47	3	3	100	-	1.9
Arsenic	3.0	4	4	100	-	**9.1**
Barium	22,000	4	4	100	-	989
Beryllium	230	4	4	100	-	0.77
Cadmium	98	3	3	100	-	0.52
Chromium	180,000	10	10	100	-	336
Hexavalent chromium [c]	6.3	-	-	-	-	-
Cyanide	13	3	2	67	0.20	0.96
Lead	800	10	10	100	-	559
Mercury	4.0	2	2	100	-	0.33
Nickel	2,200	4	4	100	-	18
Selenium	580	2	2	100	-	9.5
Silver	580	1	0	0	0.16	-
Vanadium	580	4	4	100	-	54
Zinc	35,000	4	4	100	-	135
Volatile Organic Compounds						
Benzene	5.1	8	8	100	-	0.85
2-Butanone	19,000	2	1	50	0.0060	0.0030
Carbon disulfide	350	3	3	100	-	0.039
Chlorobenzene	130	1	0	0	0.0060	-
Chloroform	1.4	1	0	0	0.0060	-
1,2-Dichloroethane	2.0	1	0	0	0.0060	-
1,4-Dioxane	23	1	0	0	0.65	-
1,1-Dichloroethylene	100	1	0	0	0.0060	-
Ethylbenzene	25	7	3	43	0.0060	2.2
Ethyl Dibromide	9.8	1	0	0	0.0060	-
Styrene	3,500	1	0	0	0.0060	-
Tetrachloroethylene	39	1	0	0	0.0060	-
1,1,1-Trichloroethane	3,600	1	0	0	0.0060	-
Trichloroethylene	1.9	1	0	0	0.0060	-
Toluene	4,700	8	7	88	0.0060	1.5
1,2,4-Trimethylbenzene	24	3	2	67	0.0060	0.0050
Xylene	250	7	5	71	0.0060	7.3
Semi-volatile Organic Compounds						
Anthracene	23,000	10	8	80	9.9	2
Acenaphthene	4,500	1	0	0	0.44	-
Benzo(a)anthracene	2.9	4	4	100	-	1.6
Benzo(b)fluoranthene	2.9	4	4	100	-	0.88
Benzo(a)pyrene	0.29	4	4	100	-	**1.1**
bis(2-ethylhexyl)phthalate	160	2	2	100	-	2.8
Butylbenzylphthalate	1,200	1	0	0	0.44	-
Chrysene	290	10	8	80	9.9	4.5
Cresol-o	4,100	1	0	0	0.44	-
Cresol-p	8,200	1	0	0	0.44	-
Dibenz(a,h)anthracene	0.29	2	2	100	-	**1.1**
1,2-Dichlorobenzene	930	1	0	0	0.44	-
1,4-Dichlorobenzene	11	1	0	0	0.44	-
7,12-Dimethylbenz(a)anthracene	0.0085	1	0	0	0.44	-
2,4-Dimethylphenol	1,600	1	0	0	0.44	-
Di-n-butylphthalate	8,200	1	0	0	0.44	-
Di-n-octylphthalate	820	1	0	0	0.44	-
Fluoranthene	3,000	3	3	100	-	0.35
Fluorene	3,000	1	1	100	-	0.22

Table 3-3
Available Characterization Data for On-Site Sediment
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	Historic Sample Results [b]				
		Number of Samples	Number of Detects	Detection Frequency (%)	Maximum Detection Limit for Non-Detects	Maximum Detected Concentration
Indeno(1,2,3-cd)pyrene	2.9	2	2	100	-	1.0
1-Methylnaphthalene	73	3	2	67	0.44	0.26
2-Methylnaphthalene	300	4	4	100	-	0.51
Naphthalene	17	8	3	38	10	12
Nitrobenzene	22	1	0	0	0.4400	-
Phenanthrene	-	10	10	100	-	25
Phenol	25,000	1	0	0	0.44	-
Pyrene	2,300	4	4	100	-	7.0
Pyridine	120	1	0	0	0.44	-

Notes:
All sample results and screening levels are presented in milligrams per kilogram (mg/kg).

% = percent
- = not applicable

Bolding of a chemical name indicates that the screening level was exceeded by a detected concentration or detection limit; **bolding** of a sample result, or reporting limit for non-detects, indicates that the screening level was exceeded by that value.

[a] United States Environmental Protection Agency Industrial Soil Regional Screening Levels (USEPA, 2014a). Screening levels for non-carcinogenic compounds are based on a hazard quotient (HQ) of 0.1.
[b] Summary statistics presented here are based on sediment sampling results from the Surface Water and Sediment Characterization Report (Total Petroleum, Inc.) dated 9/4/1990, sediment sampling results from the Phase II RFI Report (Earth Tech Inc.) dated June 2000, and one shallow soil result, from the location of SWMU 23, which was dry at the time, from the Final RFI Report (RSA) dated 8/4/1992.
[c] Speciated chromium analyses were not performed on historic samples; however sediment samples collected for the Human Health Risk Assessment will be analyzed for hexavalent chromium.

Table 3-4
Available Characterization Data for Sediment in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	1989 Sediment Characterization Sample Results [b]		
		Upstream	NPDES Outfall	Downstream
Metals				
Antimony	47	<10	<10	<10
Arsenic	3.0	<2	<2	<2
Barium	22,000	100	120	100
Cadmium	98	<2	<2	<2
Chromium	180,000	10	10	12
Hexavalent chromium [c]	6.3	-	-	-
Cobalt	35	<10	<10	<10
Lead	800	23	31	8.0
Mercury	4.0	<0.1	<0.1	<0.1
Nickel	2,200	<10	<10	0.090
Selenium	580	<1	<1	<1
Vanadium	580	<200	<200	<200
Zinc	35,000	-	-	-
Volatile Organic Compounds				
Acetone	67,000	<10	<10	<10
Benzene	5.1	<0.4	0.70	<0.4
2-Butanone	19,000	<50	<50	<50
Carbon disulfide	350	<10	<10	<10
Carbon tetrachloride	2.9	<0.7	<0.7	<0.7
Chlorobenzene	130	1.8	<0.4	<0.4
Chloroform	1.4	<0.5	<0.5	<0.5
1,2-Dichloroethane	2.0	<0.6	<0.6	<0.6
1,4-Dioxane	23	**<50**	**<50**	**<50**
1,1-Dichloroethylene	100	<0.6	<0.6	<0.6
Ethylbenzene	25	1.7	<0.7	<0.7
Ethyl Dibromide	9.8	<1	<1	<1
Styrene	3,500	<0.5	<0.5	<0.5
Toluene	4,700	<0.4	<0.4	<0.4
Trichloroethylene	1.9	<0.6	<0.6	<0.6
Xylene	250	9.9	6.2	2.4
Semi-volatile Organic Compounds				
Anthracene	23,000	<500	<500	<500
Acenaphthene	4,500	<500	<500	<500
Benzenethiol	120	**<500**	**<500**	**<500**
Benzo(a)anthracene	2.9	**<500**	**<500**	**<500**
Benzo(b)fluoranthene	2.9	**<500**	**<500**	**<500**
Benzo(k)fluoranthene	29	**<500**	**<500**	**<500**
Benzo(a)pyrene	0.29	**<500**	**<500**	**<500**
bis(2-ethylhexyl)phthalate	160	**<500**	**<500**	**<500**
Butylbenzylphthalate	1,200	<500	<500	<500
Chrysene	290	**<500**	**<500**	**<500**
Cresols	8,200	<500	<500	<500
Dibenzofuran	100	**<500**	**<500**	**<500**
Dichlorobenzene	-	<500	<500	<500
Diethylphthalate	66,000	<500	<500	<500

Table 3-4
Available Characterization Data for Sediment in the Walnut River
MRP Properties Company, LLC - Arkansas City, Kansas

Constituent	Screening Level [a]	1989 Sediment Characterization Sample Results [b]		
		Upstream	NPDES Outfall	Downstream
7,12-Dimethylbenz(a)anthracene	0.0085	**<500**	**<500**	**<500**
2,4-Dimethylphenol	1,600	<500	<500	<500
Dimethylphthalate	-	<500	<500	<500
2,4-Dinitrophenol	160	**<5000**	**<5000**	**<5000**
Di-n-butylphthalate	8,200	700	3200	900.0
Di-n-octylphthalate	820	<500	<500	<500
Dinbz(a,h)acridine	-	<500	<500	<500
Dinbz(a,h)anthracene	0.29	**<500**	**<500**	**<500**
Fluoranthene	3,000	<500	<500	<500
Fluorene	3,000	<500	<500	<500
Indene	-	<500	<500	<500
Methyl chrysene	-	<500	<500	<500
1-Methylnaphthalene	73	**<500**	**<500**	**<500**
2-Methylnaphthalene	300	**<500**	**<500**	**<500**
Naphthalene	17	**<500**	**<500**	**<500**
4-Nitrophenol	-	<500	<500	<500
Phenanthrene	-	<500	<500	<500
Phenol	25,000	<500	<500	<500
Pyrene	2,300	<500	<500	<500
Pyridine	120	**<500**	**<500**	**<500**
Quinoline	0.77	**<500**	**<500**	**<500**

Notes:
All sample results and screening levels are presented in milligrams per kilogram (mg/kg).

- = not applicable; analysis not performed or screening value not available for this chemical
< = analyte not detected; value shown is the detection limit
NPDES - National Pollutant Discharge Elimination System

Bolding of a chemical name indicates that the screening level was exceeded by a detected concentration or detection limit; **bolding** of a result value indicates that the screening level was exceeded by that value.

[a] United States Environmental Protection Agency Industrial Soil Regional Screening Levels (USEPA, 2014a). Screening levels for non-carcinogenic compounds are based on a hazard quotient (HQ) of 0.1.

[b] Detected concentration or reporting limit from samples collected upstream, at the NPDES outfall, and downstream of the Site, as reported in the Surface Water and Sediment Characterization Report (Total Petroleum, Inc.) dated 9/4/1990.

[c] Speciated chromium analyses were not performed on historic samples; however sediment samples collected for the Human Health Risk Assessment will be analyzed for hexavalent chromium.

Table 4-1
Modeling Assumptions to be Used in the Human Health Risk Assessment for Surface Water and Sediment
MRP Properties Company, LLC - Arkansas City, Kansas

Exposure Parameter	Units	Current / Future Commercial or Industrial Worker		Future Utility or Construction Workers		Off-Site Recreational User: Adolecsent		Off-Site Recreational User: Adult	
General									
BW = body weight	kg	80	a	80	a	56.8	b	80	a
SA = surface area	cm^2	3,470	a	3,470	a	4,113	c	5,715	c
ATc = averaging time for carcinogens	days	25,550	a	25,550	a	25,550	a	25,550	a
ATn = averaging time for non-carcinogens	days	9,125	a	365	d	1,825	e	9,125	e
ED = exposure duration	years	25	a	1	d	5	e	25	e
Exposure Modeling Parameters for Dry Ponds									
IR_S = dry sediment ingestion rate	mg / day	100	a	330	f	-			
AF = soil-to-dermal adherence factor	mg / cm^2	0.12	a	0.3	f	-			
ABS = absorption fraction through skin for chemicals in sediment	unitless	CS		CS		-			
ET = exposure time for inhalation	hours / 24 hr day	8 / 24	g	8 / 24	g	-			
VF = volatilization factor for constituents from sediment	m^3 / kg	CS		CS		-			
PEF = particulate emission factor	m^3 / kg	SS	h	SS	h	-			
EF = exposure frequency	days / year	26	g	50	d	-			
Exposure Modeling Parameters for Wet Ponds									
IR_S = sediment ingestion rate	mg / day	100	a	330	a	-			
IR_W = water ingestion rate	mL / hour	10.6	i	21	j	-			
DA = absorbed dose per dermal contact	mg / cm^2-event	CS		CS		-			
VF = volatilization factor for constituents from water	m^3 / kg	CS		CS		-			
ET = exposure time for inhalation and dermal cotnact	hours / 24 hr day	8 / 24	g	8 / 24	g	-			
EF = exposure frequency	days / year	8	g	50	d	-			
Exposure Modeling Parameters for the Walnut River									
IR_S = sediment ingestion rate	mg / day	-		-		200	a	100	a
IR_W = water ingestion rate	mL / hour	-		-		49	i	21	i
DA = absorbed dose per dermal contact	mg / cm^2-event	-		-		CS		CS	
VF = volatilization factor for constituents from water	m^3 / kg	-		-		CS		CS	
ET = exposure time for dermal contact	hours / 24 hr day	-		-		0.75 / 24	e	0.75 / 24	e
EF = exposure frequency	days / year	-		-		52	e	52	e
Fish Ingestion Rate	mg / day	-		-		0.054	a	0.054	a

Notes

cm^2 - square centimeters
CS - chemical-specific
kg - kilogram
m^3/kg - cubic meters per kilogram
mg/cm^2 - milligrams per square centimeter
mg/day - milligrams per day
mL/hour - milliliters per hour
NA - not applicable
SS - site-specific
USEPA - U.S. Environmental Protection Agency

[a] USEPA (2014b) Human Health Evaluation Manual, Supplemental Guidance: Update of Standard Default Exposure Factors. OSWER 9200.a-120. February. Exposure parameters for the commercial or industrial receptor are equal to the outdoor industrial

[b] Adolescent (11 to 16 years of age) body weight from Table 8-1 of the USEPA's Exposure Factors Handbook (USEPA, 2011).

[c] Skin surface area for a recreational user fishing and wading in the Walnut River is equal to the sum of the hands and feet surface area, half of the arm and a quarter of the leg surface area in Table 7-2 of the USEPA's Exposure Factors Handbook (USEPA, 2011). Surface area for an 11 to 16 year old adolescent is for males and females combined; the surface area for an adult is for a male, as this will be protective of a female recreator.

Table 4-1
Modeling Assumptions to be Used in the
Human Health Risk Assessment for Surface Water and Sediment
MRP Properties Company, LLC - Arkansas City, Kansas

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[d] A construction or utility worker is assumed to be on Site 50 days over the course of one year. Although work would likely take place during the summer months, it is conservatively assumed that this work takes place either entirely during the period when the pond is dry, or when the pond has water in it. The risk results from each scenario will be presented in the risk assessment report.

[e] A recreational user is assumed to use the Walnut River for fishing for eight hours per day, one day per weekend during the spring, summer, and fall, for 5 years as an adolescent and 25 years as an adult. The exposure time for dermal contact with surface water during activities such as wading and hand washing is assumed to be 45 minutes out of the 8 hour day.

[f] USEPA (2002) Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites. OSWER 9355.4-25. December. Exposure parameters for the commercial or industrial receptor are equal to the outdoor industrial worker.

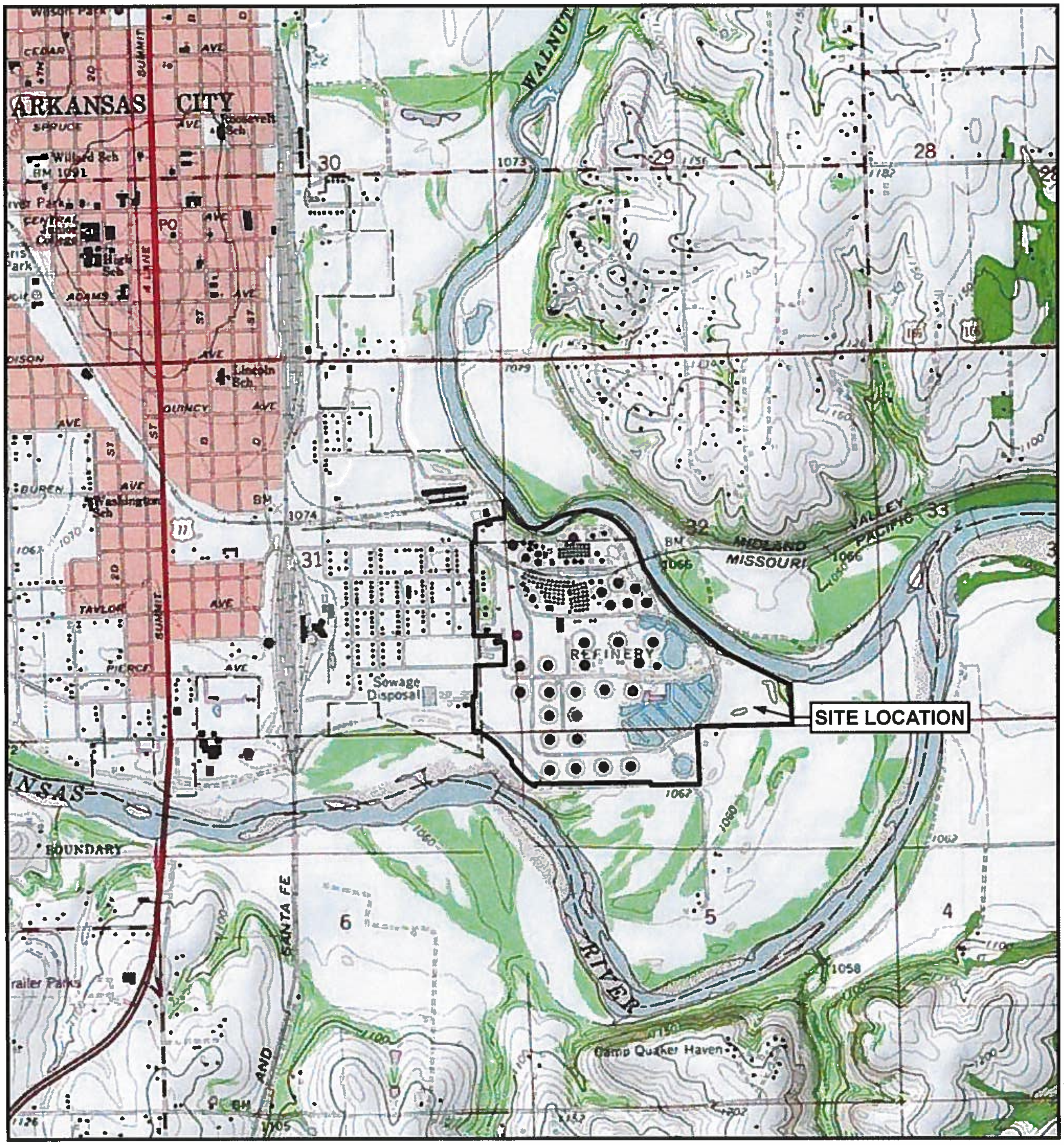
[g] A worker at an industrial or commercial facility is expected to spend a day mowing or otherwise maintaining the area around the ponds once a week during April through September (i.e., 26 weeks per year). It is further assumed that the ponds will have no water in them during this period, such that the outdoor worker is exposed to dry pond sediment only. Although it is unlikely that the ponds would recieve significant enough rain during late spring or early fall, it is possible that an outdoor worker would be exposed to wet pond sediment and surface water for 8 weeks per year. A construction or utility worker working on in the pond is expected to be exposed to media for a 8 hour work day.

[h] Pond-specific particulate emission factors will be calculated according to the site area for each pond according to modeling parameters and methods in Appendix D of USEPA (2002) for a future commercial / industrial worker, and methods and modeling parameters in Appendix E for a future construction / utility worker.

[i] Ingestion rate for a future outdoor worker is equal to the upper confidence limit on the mean incidental water ingestion rate for walking in water from Table 3-93 of the Exposure Factor Handbook (USEPA, 2011). As described in EPA Comments on the draft Human Health Risk Assessment for Surface Water and Sediment Work Plan dated September 3, 2014, the incidential ingestion rate for wading is equal to the mean value from Table 3-5 of USEPA (2011).

[j] Default incidential ingestion rate for construction workers recommended by Region 7 EPA in the September 3, 2014 Comments on the Human Health Risk Assessment for Surface Water and Sediment Work Plan.

FIGURES



EXPLANATION

SITE BOUNDARIES ARE APPROXIMATE.
SOURCE: USDA-NRCS-NCGC DIGITAL RASTER GRAPHIC (DRG) MrSID MOSAIC.
CONTOUR INTERVAL: 10 FEET.
NATIONAL GEODETIC VERTICAL DATUM OF 1929.
NORTH AMERICAN HORIZONTAL DATUM OF 1983 (NAD83).
ARKANSAS CITY, KANSAS. N3700-W9700/7.5. 1965; PHOTOREVISED 1979.
AMS 6558 II SE-SERIES V878

SCALE 1: 24,000

0 0.5 1 MILE

0 2,000 4,000 FEET

DATE	DESIGN BY	DRAWN BY	REVIEWED BY
11/18/2013	RPH	RPH	JFM

TITLE:

SITE LOCATION MAP

PROJECT:

MRP PROPERTIES COMPANY, LLC
ARKANSAS CITY, KANSAS

MWH

Figure No.: **1-1**

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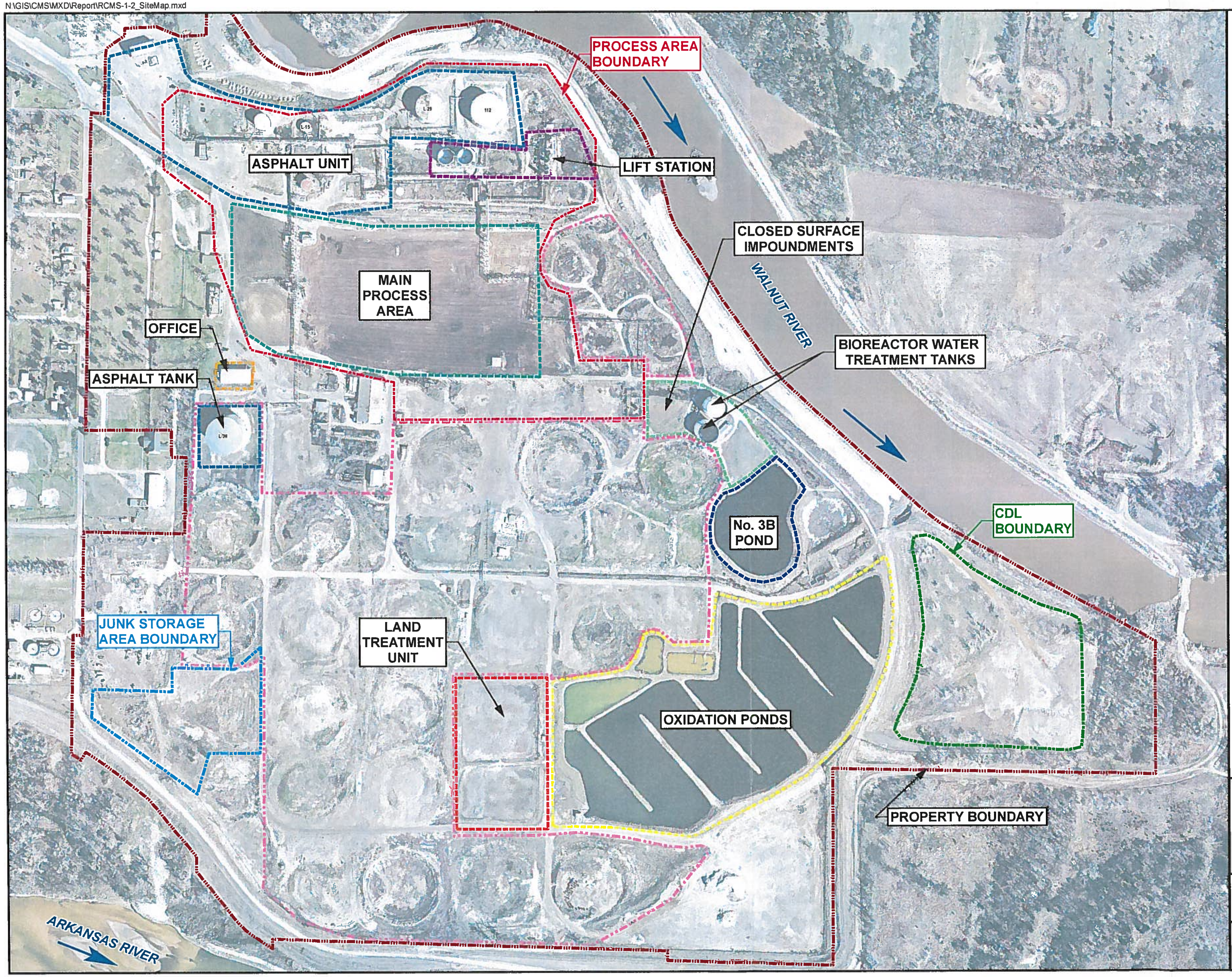


EXPLANATION

APPROXIMATE PROPERTY BOUNDARY

INVESTIGATION AREAS

- PROCESS AREA BOUNDARY
- JUNK STORAGE AREA BOUNDARY
- CDL BOUNDARY

SITE FEATURES (APPROXIMATE EXTENTS)

- ASPHALT TANK
- ASPHALT UNIT
- CLOSED SURFACE IMPOUNDMENTS (CSI)
- LAND TREATMENT UNIT (LTU)
- LIFT STATION
- MAIN PROCESS AREA
- No. 3B POND
- OFFICE
- OXIDATION PONDS
- FORMER TANK FARM

N
W E
S

SCALE IN FEET

0 400 800

AERIAL PHOTO:
MARCH 12, 2005

REVISION	DATE	DESIGN BY	DRAWN BY	REVIEWED BY
Revision 2	7/17/2014	JFM	CCL	JFM

TITLE:

SITE PLAN

PROJECT:

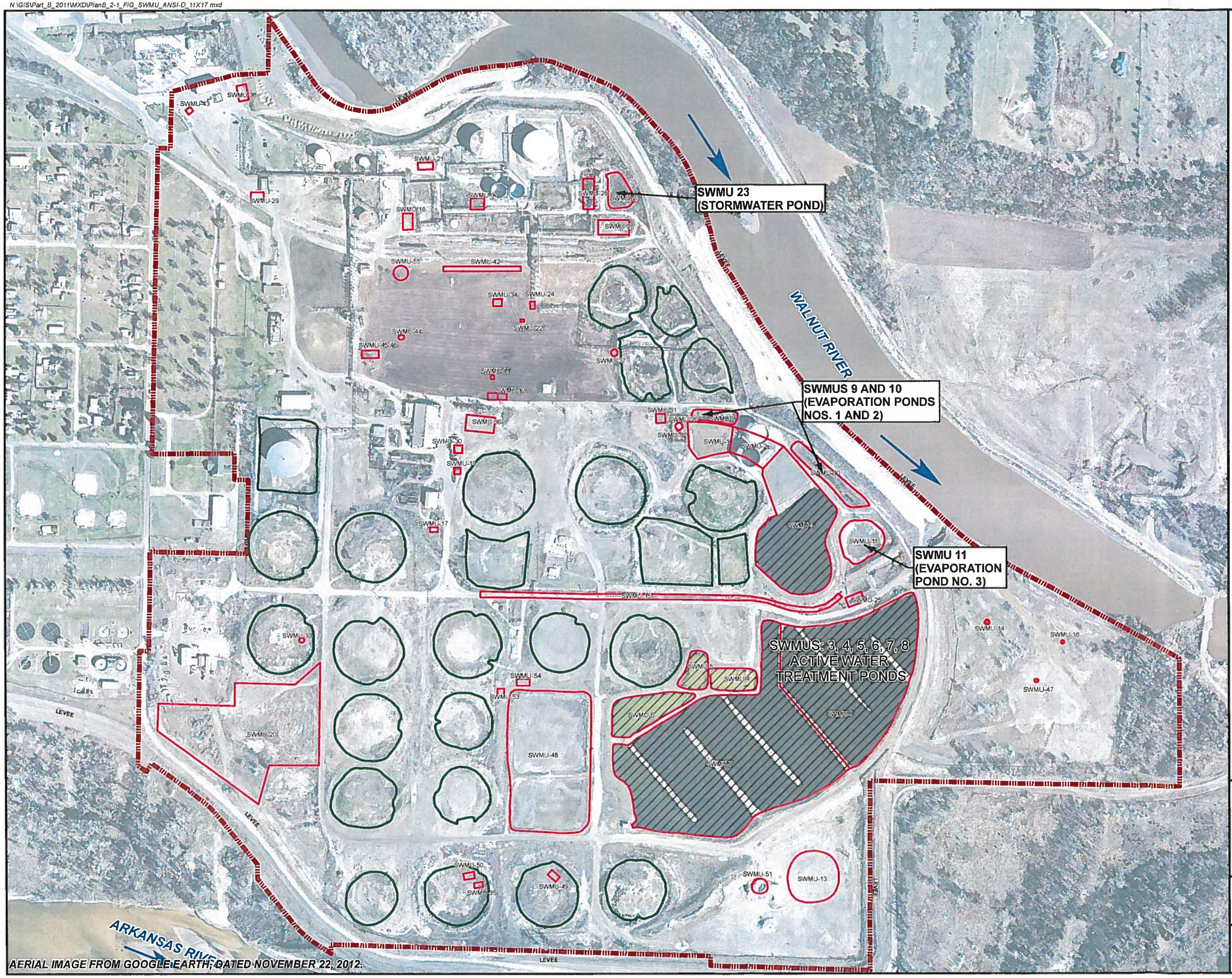
MRP PROPERTIES COMPANY, LLC
ARKANSAS CITY, KANSAS

MWH

Figure No.:

1-2

N:\GIS\Part_B_2011\MXD\PlanB_2-1_FIG_SWMU_ANSI-D_11X17.mxd



EXPLANATION

- FACILITY PROPERTY BOUNDARY
- SWMU-52 LOCATIONS
- SWMU LOCATIONS

NOTE:

APPROXIMATE EXTENT OF WALNUT RIVER IN 1996 TRACED FROM AERIAL IMAGE FOUND IN GOOGLE EARTH, DATED MARCH 19, 1996.

N
W E
S

SCALE IN FEET

0 500 1,000

AERIAL PHOTO:
NOVEMBER 22, 2012

REVISION	DATE	DESIGN BY	DRAWN BY	REVIEWED BY
A	7/18/2014	JFM	SLG	JFM

TITLE:

SWMU LOCATION MAP

PROJECT:

MRP PROPERTIES COMPANY, LLC
ARKANSAS CITY, KANSAS

MWH

Figure No.: **2-1**

N:\GIS\RISK ASSESSMENT_MXDs\RA_002-2_Walnut River Comparisons.mxd

EXPLANATION

- APPROXIMATE EXTENT OF WALNUT RIVER IN 1999
- DIRECTION OF SURFACE WATER FLOW
- FACILITY PROPERTY BOUNDARY
- SURFACE WATER SAMPLE LOCATIONS
- LOCATION OF HISTORIC HYDROCARBON SEEPS

NOTE:
APPROXIMATE EXTENT OF WALNUT RIVER IN 1996 TRACED FROM AERIAL IMAGE FOUND IN GOOGLE EARTH, DATED MARCH 19, 1996

N
W E
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SCALE IN FEET
0 500 1,000

AERIAL PHOTO:
NOVEMBER 22, 2012

REVISION	DATE	DESIGN BY	DRAWN BY	REVIEWED BY
A	7/18/2014	CCL	CCL	JFM

TITLE:

PHASE II RFI WALNUT RIVER SURFACE WATER SAMPLE LOCATIONS

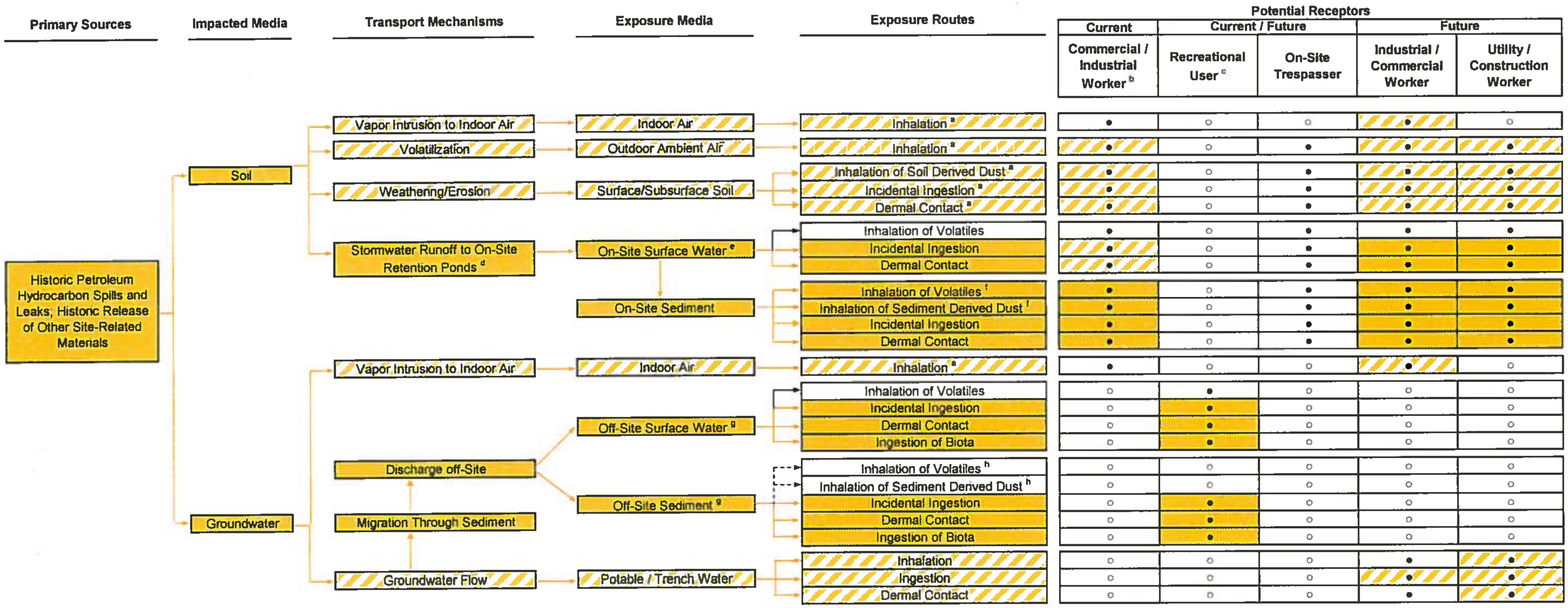
PROJECT:

MRP PROPERTIES COMPANY, LLC
ARKANSAS CITY, KANSAS

MWH

Figure No.:
2-2

Figure 4-1
Human Health Conceptual Site Model for Surface Water and Sediment
MRP Properties Company, LLC - Arkansas City, Kansas



Notes:

Complete Exposure Pathway
Potentially Complete but Insignificant Pathway
Incomplete Pathway

Complete Exposure Pathway - Evaluated in the Soil and Groundwater HHRA for the Site (refer also to the Conceptual Site Model in the Soil and Groundwater HHRA for complete soil and groundwater pathways)
Complete Exposure Pathway
Potentially Complete but Insignificant Pathway
Incomplete Exposure Pathway

[a] Complete exposure pathways for soil are evaluated in the Human Health Risk Assessment for Soil and Groundwater (MWH, 2014).
[b] Current industrial receptors at the Site include workers at the asphalt terminal and maintenance workers at the facility. Although complete exposure pathways between these receptors and Site media exist, these pathways are expected to be insignificant compared with exposures associated with future receptors, and therefore will not be quantitatively evaluated.
[c] Recreational users include adolescents and adults who use the Walnut River for fishing; this pathway includes wading exposures.
[d] Per discussion between MWH and KDHE on May 7, 2014, exposure associated with surface water in the active treatment ponds operating under a NDPES permit will not be evaluated at this time.
[e] Exposure to surface water in storm water in evaporation ponds and the stormwater pond is limited due to the infrequent occurrence of standing water.
[f] Inhalation of volatiles and sediment derived particulates is a complete exposure pathway during the dry season when the stormwater ponds are dry.
[g] The potential migration of contaminants from groundwater to surface water and sediment is currently incomplete because contaminated water is captured and treated prior to discharge to the Walnut River under a NPDES permit. However, the migration of contaminants in on-Site groundwater to surface water and sediment within the Walnut River may have occurred prior to installation and start-up the groundwater extraction and treatment system.

Revised September 30, 2014